Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1952

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DETROIT

MESTA heavy duty ROLL GRINDERS

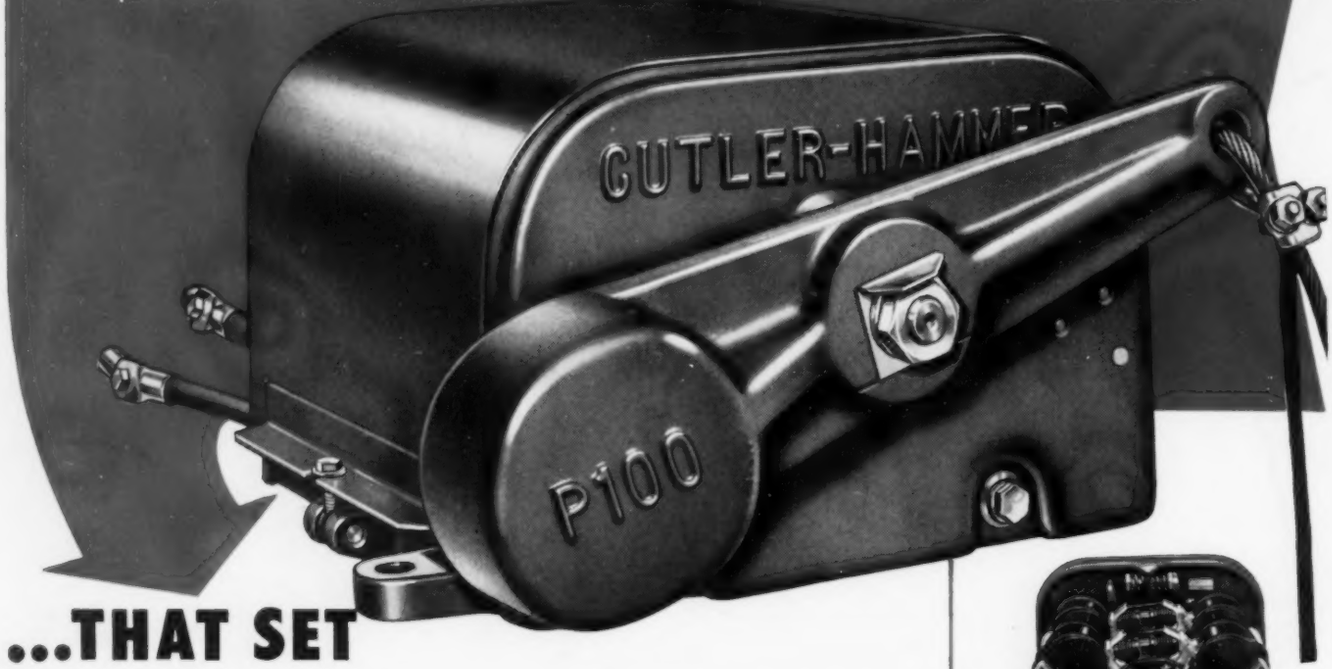
Color Photo by E. D. MESTA

Mesta Roll Grinders of simplified design are the most accurate and dependable grinding machines available today. Built with precision for the finest finishing and with ruggedness for the heaviest roughing.

DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.

the Crane SAFETY LIMIT STOP



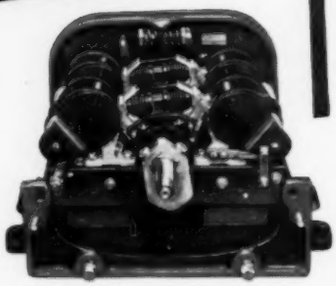
...THAT SET *New Standards of Performance*

There probably has never been a crane safety limit stop switch that so completely embodies *all* the wants of steel mill engineers as the Type P-100 Cutler-Hammer Safety Limit Stop, for 41 to 100 H.P. installations or the P-200 Safety Limit Stop for 101 to 200 H.P. installations. This is demonstrated by the fact that time after time engineers have taken one look at it and said: "That is what I want".

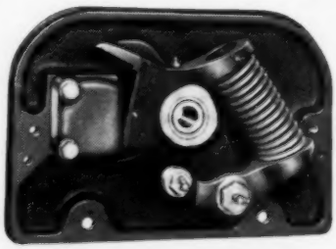
C-H Type P-100 100 H. P.

C-H Type P-200 200 H. P.

The photographs shown here tell their own story . . . a story of simple design . . . of rugged construction . . . of dependable, unfailing operation. The Cutler-Hammer Crane Safety Limit Stop has set new standards of performance every time, every way. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate*: Canadian Cutler-Hammer, Ltd., Toronto.



Movable contacts and arc shields in position. (Operating head removed).



Inside view of removable head, showing snap action mechanism.

Combined operating lever and tripping weight cable.

CHECK THESE OUTSTANDING FEATURES

Low headroom required.

Totally enclosed tripping mechanism—can't be made inoperative by rain, snow, ice, dirt or falling objects.

Slate contact supports, slotted, provide ample insulation to ground.

Snap action make and break —hammer blow of tripping is absorbed by spring bumper.

Cover strong enough to support a man's weight.

Rigid one-piece construction of operating lever and tripping weight.

Only one hanging weight, and that has double guides, adjustable to meet any practical installation condition, to prevent fouling the weight by the hoisting cables.

The snap action is obtained from a compression spring, with a very low unit stress. Even if it should break, the mechanism will operate because spring is held in place by an inside guide.

Ball bearings, with means for lubricating by standard grease fittings, used throughout.

Flexible leads brought out for ease of installation.

Gasketed cover to keep out dirt.

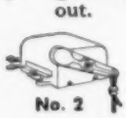
Mounting interchangeable with old style P-2.

Blowouts latched in place when mounted in position (3) or (4).

Cover chained to case to prevent dropping to ground during inspection.

(Below) Operating lever can be mounted in any of 4 quadrants.

No. 1



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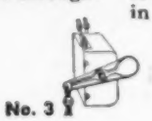
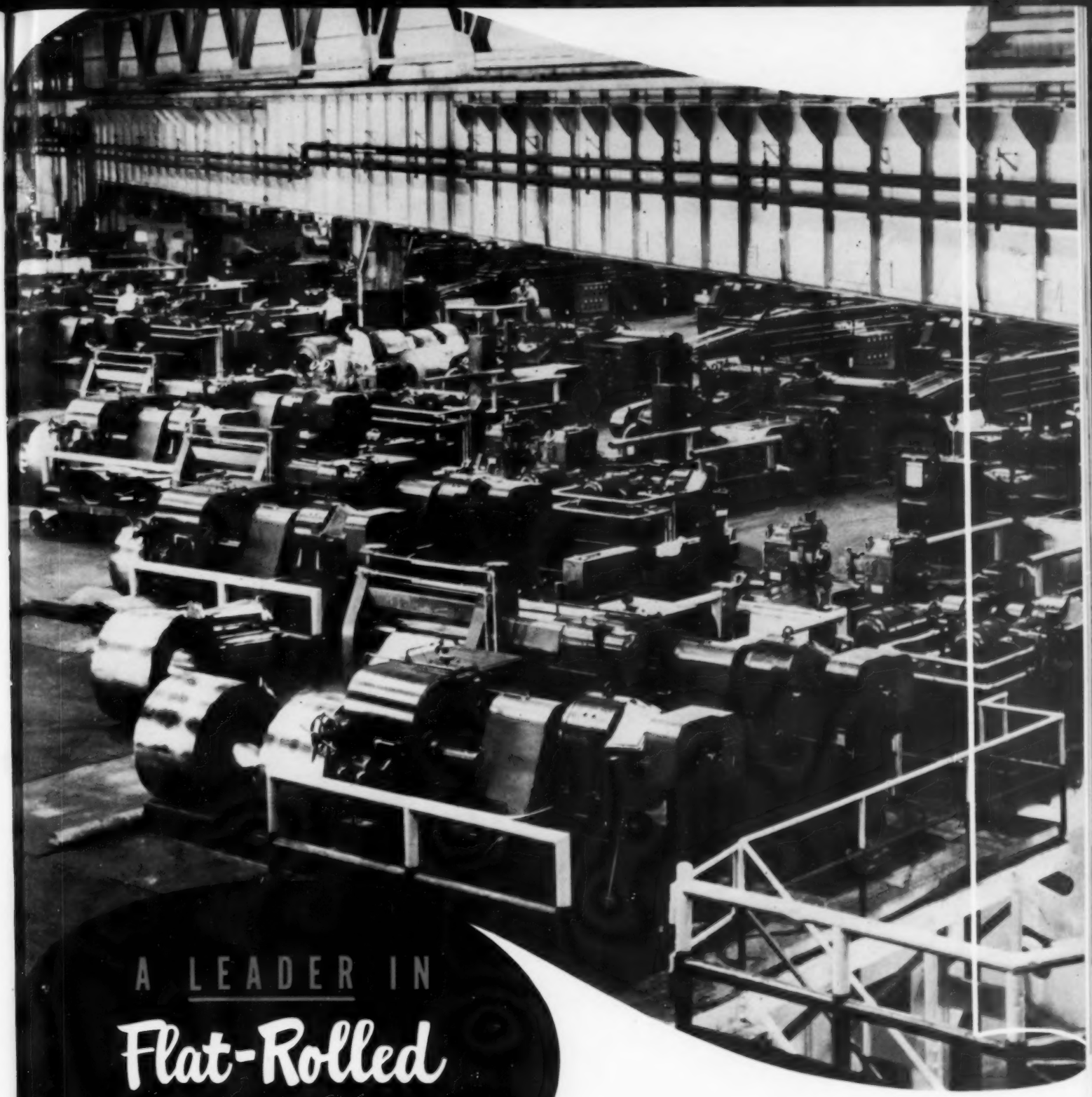


No. 3

No. 4

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania, under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 29, No. 8.



A LEADER IN

Flat-Rolled

FINISHING EQUIPMENT

Aetna-Standard

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Plants in Warren, Ohio · Ellwood City, Pennsylvania

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Head Wrightson Machine Company, Ltd., Middlesbrough, England—Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.

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Compagnia Italiana Forme Acciaio, Milano, Italy—Italy.

Aetna-Japan Company, Ltd., Tokyo, Japan—Japan.

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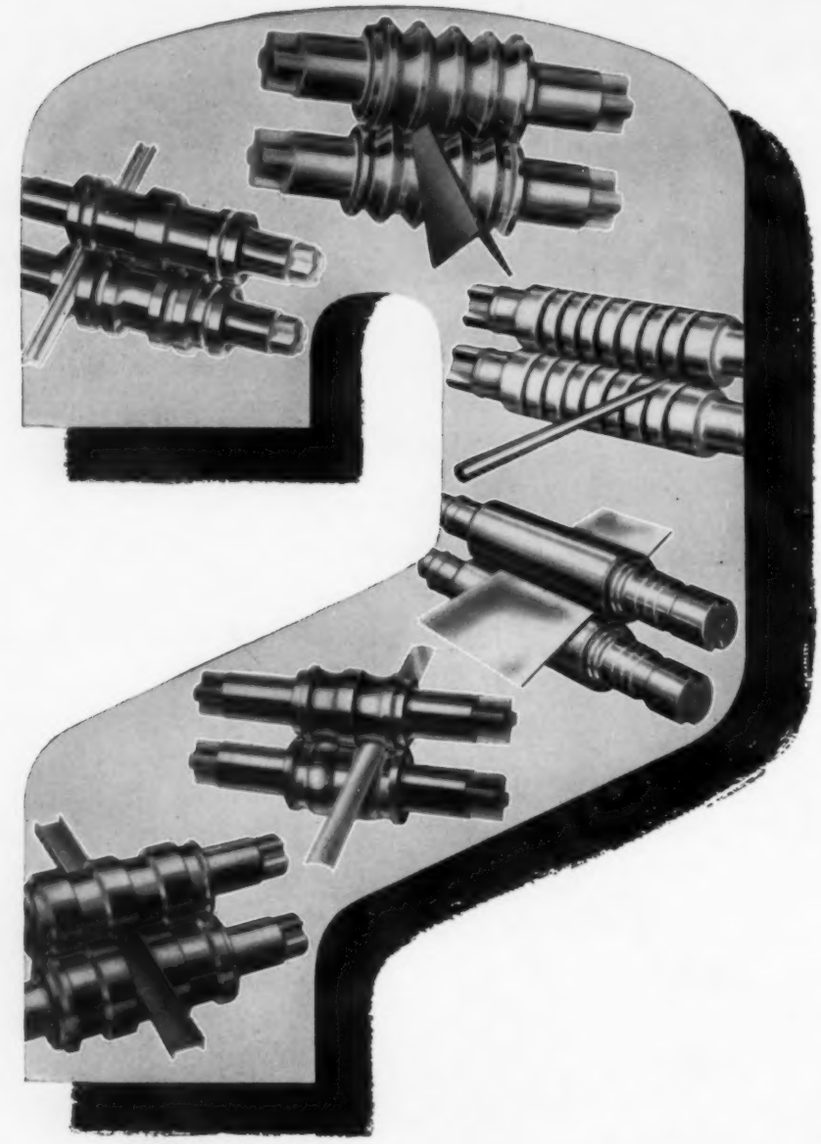


WHAT ARE *Your* ROLL REQUIREMENTS

Whatever type of rolls you require—for rolling sheet, strip and plate or forming shapes, National has the experienced metallurgical staff and the modern manufacturing facilities to produce them to your requirements.

THE NATIONAL ROLL & FOUNDRY CO.
AVONMORE, PENNSYLVANIA
Specialists in Iron and Alloy Iron Rolls

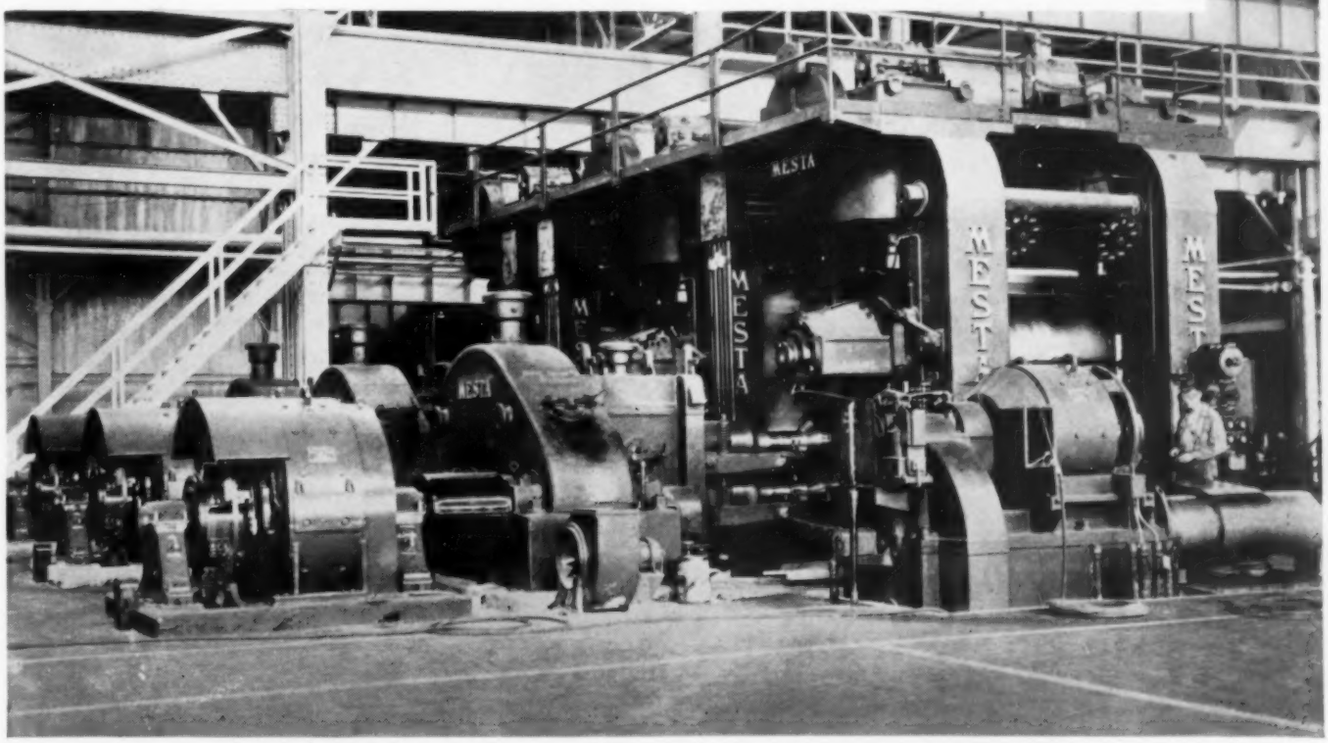
MAKE A "TOOTHSOME" SAVING—protect reduction gears with TEXACO MEROPA LUBRICANT

There's no better protection for the teeth of your enclosed reduction gears than *Texaco Meropa Lubricant*. It's designed to carry the heaviest loads . . . ward off wear and corrosion. Gears last longer, you make a "toothsome" saving on maintenance costs.

Texaco Meropa Lubricant is strongly oxidation-resistant. It does not thicken or foam. It will not separate in service, storage, centrifuging or in central pressure systems. *Texaco Meropa Lubricant* protects bearings as well as gears.

To save on maintenance costs for oil film bearings on back-up rolls, lubricate with *Texaco Regal Oil*. This heavy-duty, turbine-quality oil resists oxidation and sludging. Keeps systems clean, bearings fully protected. On open gears use *Texaco Crater X Fluid*.

A Texaco Lubrication Engineer will gladly work with you to reduce costs throughout your mill. Just call the nearest of the more than 2,000 Texaco Distributing Plants in the 48 States, or write The Texas Company, 135 East 42nd Street, New York 17, N. Y.



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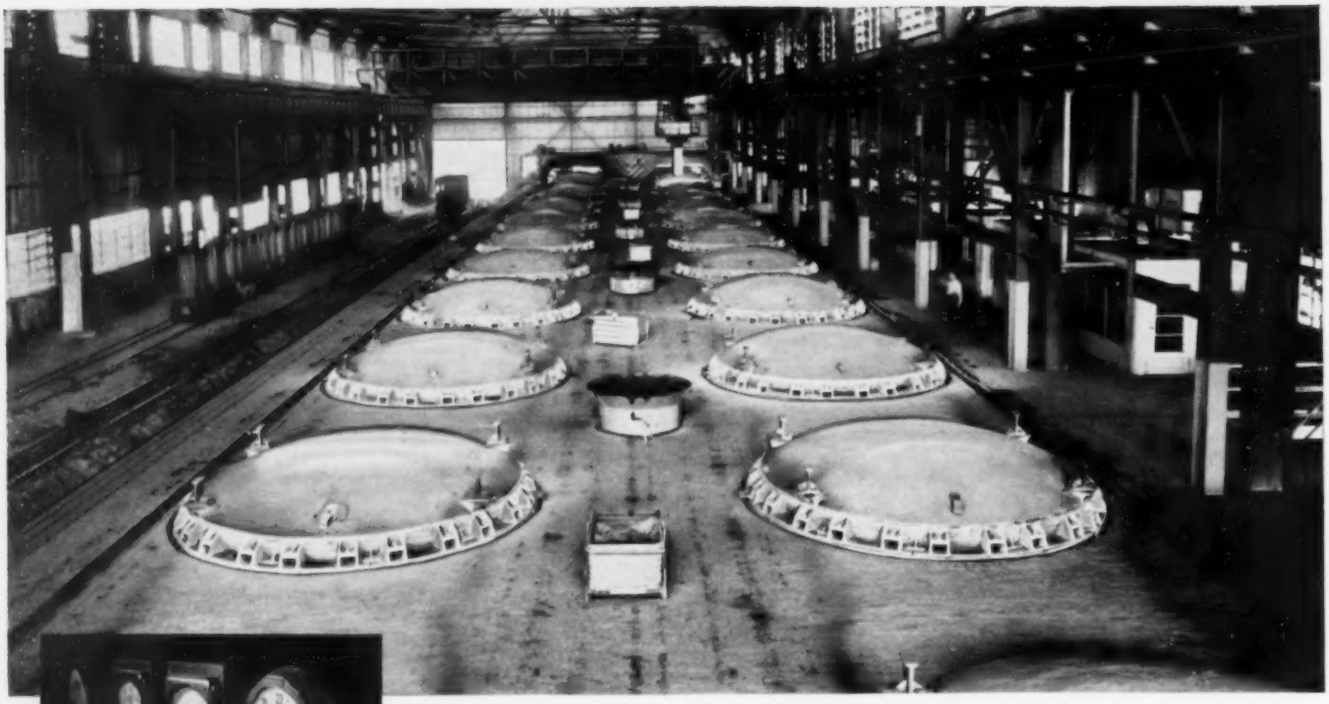
FOR STEEL MILL GEAR DRIVES

Faithfully yours
TEXACO 50
for Fifty Years



◂ Partial view of one of the control panels for C.F. & I. soaking pits. Heater is opening Micromax Controller case to change temperature control point.

▴ Part of C.F. & I.'s battery of 24 Salem soaking pit furnaces in Pueblo, Colo. plant. Control panels are in cubicles in right hand bay.

How C. F. & I. controls pit furnaces to give ingots

correct TEMPERATURE *and* SURFACE

The idea of employing instruments wherever they can be effective is doing a major job for Colorado Fuel & Iron Co. Engineers of C.F. & I. and of Salem Engineering Co. applied it with outstanding success in the soaking pits shown above. The net result is a plentiful supply of well-heated, properly-surfaced ingots from the big battery of 24 Salem round pit furnaces.

Regulation of the furnaces includes automatic control of temperature, combustion (fuel-air ratio) and draft (furnace pressure) in that order. The Micromax Temperature Recording Controllers preserve correct temperatures despite the effects of charging and pulling ingots, and changes in ambient conditions. With this basic fact of temperature under firm control, the other instruments can hold the equally important combustion factors at their correct respective settings. Furnace atmosphere can be made either neutral, oxidizing or reducing at any operating temperature. Draft can be made to hold the products of combustion to their proper path through the furnace for any operating load of ingots.

The L&N line today includes instruments, controllers and accessories in far greater variety than ever before. From among these standard equipments we can help you assemble control panels that are tailored exactly to the needs of any pit furnace . . . or any other industrial furnace. Just contact our nearest office or write us at 4942 Stenton Ave., Phila. 44, Penna.

LEEDS instruments NORTHRUP automatic controls • furnaces

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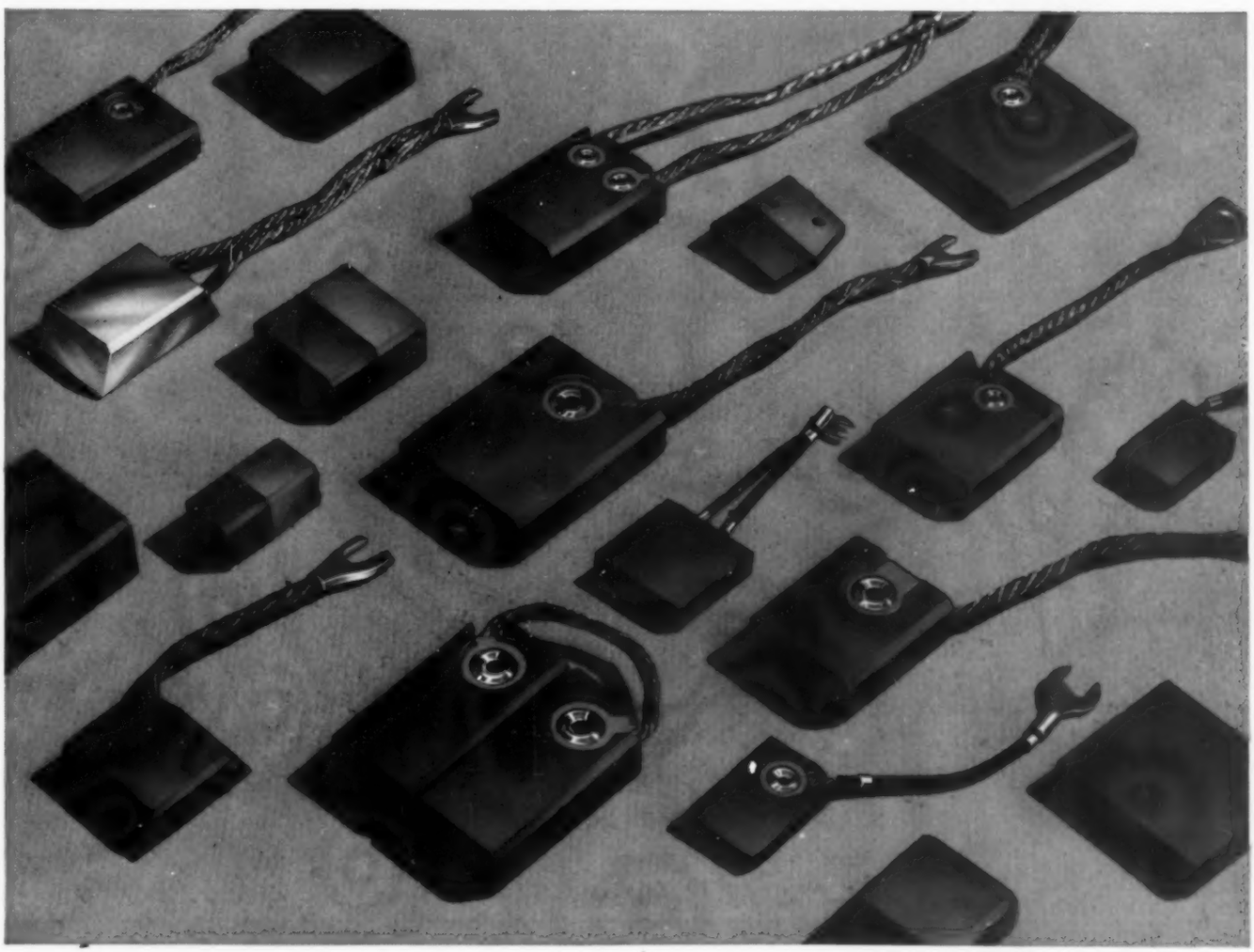
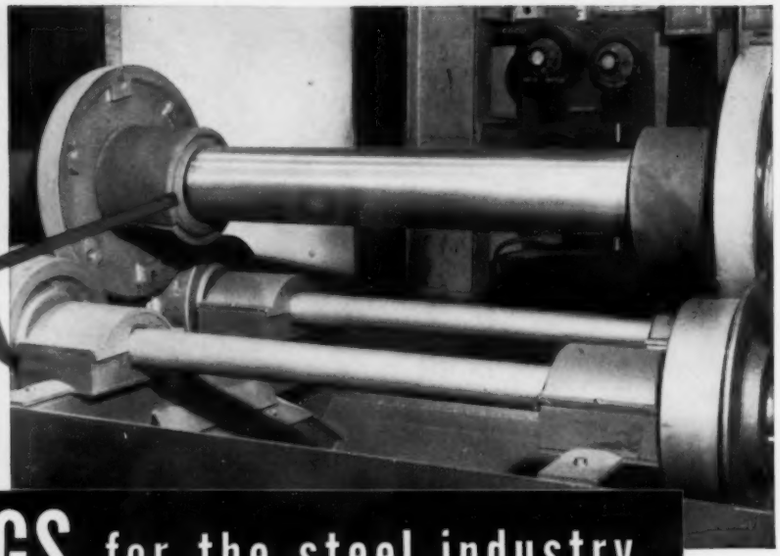


90-B

THE UNITED STATES GRAPHITE COMPANY

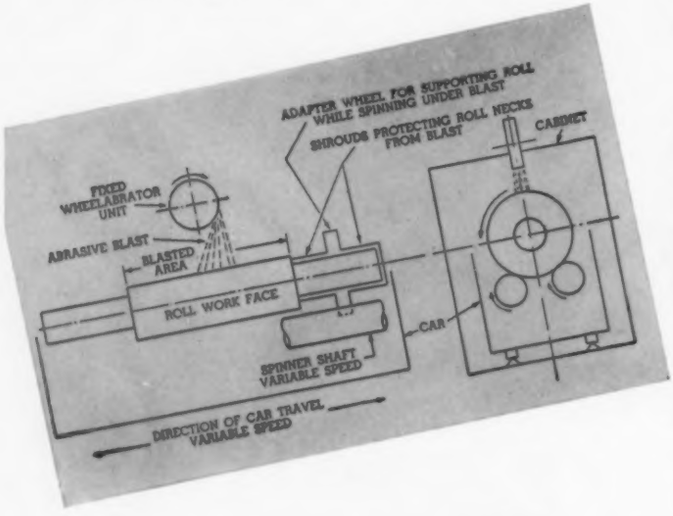
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN



NEW SAVINGS for the steel industry

Etching mill rolls with the Airless WHEELABRATOR®

The Wheelabrator opens new horizons in cost-savings possibilities for steel mills in the etching of mill rolls used in temper mills. In a typical installation at the Weirton Steel Company, 8 to 9 inch diameter rolls are etched in just 54 seconds blasting time. Large 26 and 27 inch diameter rolls used in the cold mill, are etched in 3 minutes blasting time.



The diagram shows the airless Wheelabrator method of roll etching. This exclusive development conveys and rotates the work under a fixed and constant rectangular blast from the wheel.

PAYS FOR ITSELF THROUGH SAVINGS

Weirton previously roughened its temper mill rolls by passing emery paper between the rolls after installation in the mill. By eliminating use of emery paper for the initial etching of ground rolls, the Wheelabrator will more than pay for itself through savings in the cost of paper alone. Another big advantage is that it provides a better shape to the roll which means better gripping in the mill. Wheelabrating also provides an etch of a more uniform depth and texture which insures an improved surface on the steel sheet.

AN IMPROVEMENT OVER AIRBLASTING

The Wheelabrator roughens mill rolls in 1 to 3 minutes that commonly takes from 10 to 30 minutes in conventional airblast machines. It produces a uniform etch automatically at a greatly reduced cost per roll. It is a proved fact that rolls so etched have a materially increased life in the mill with a resulting increase in tons rolled per set of rolls.

Write today for complete information.

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WHEELABRATOR & EQUIPMENT CORP.
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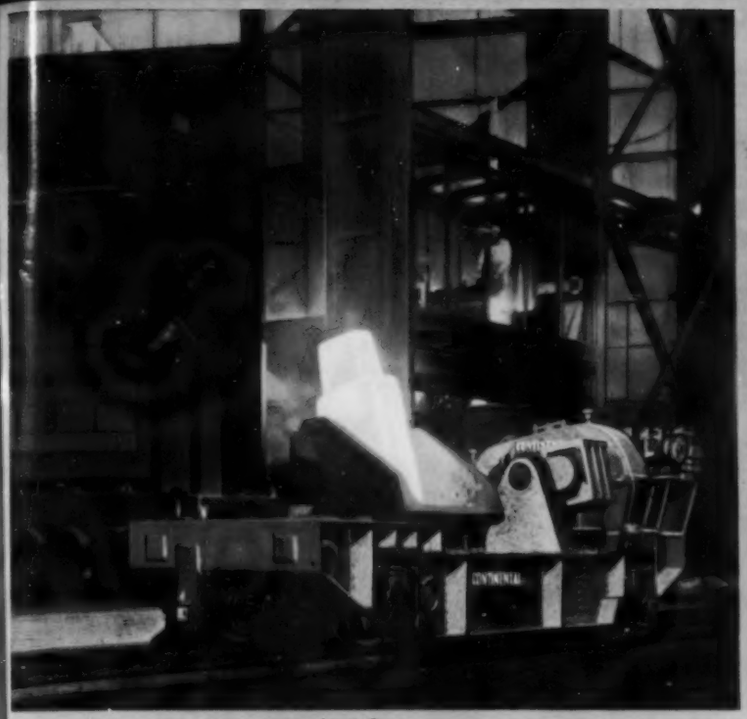
Wheelabrator® AIRLESS BLAST CLEANING

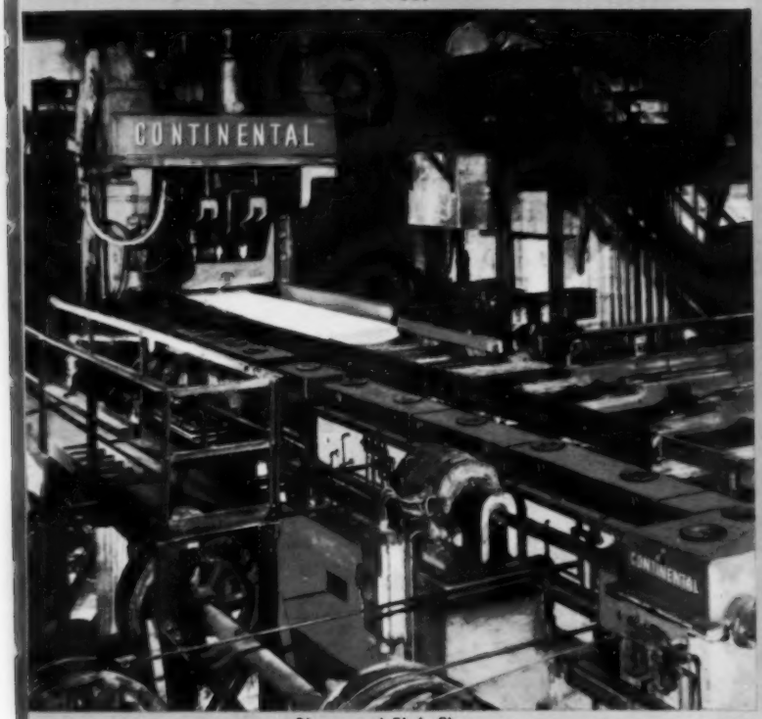
D-3575

WORLD'S LARGEST BUILDERS OF AIRLESS BLAST EQUIPMENT



Ingot Buggy

High Lift Blooming-Slabbing Mill



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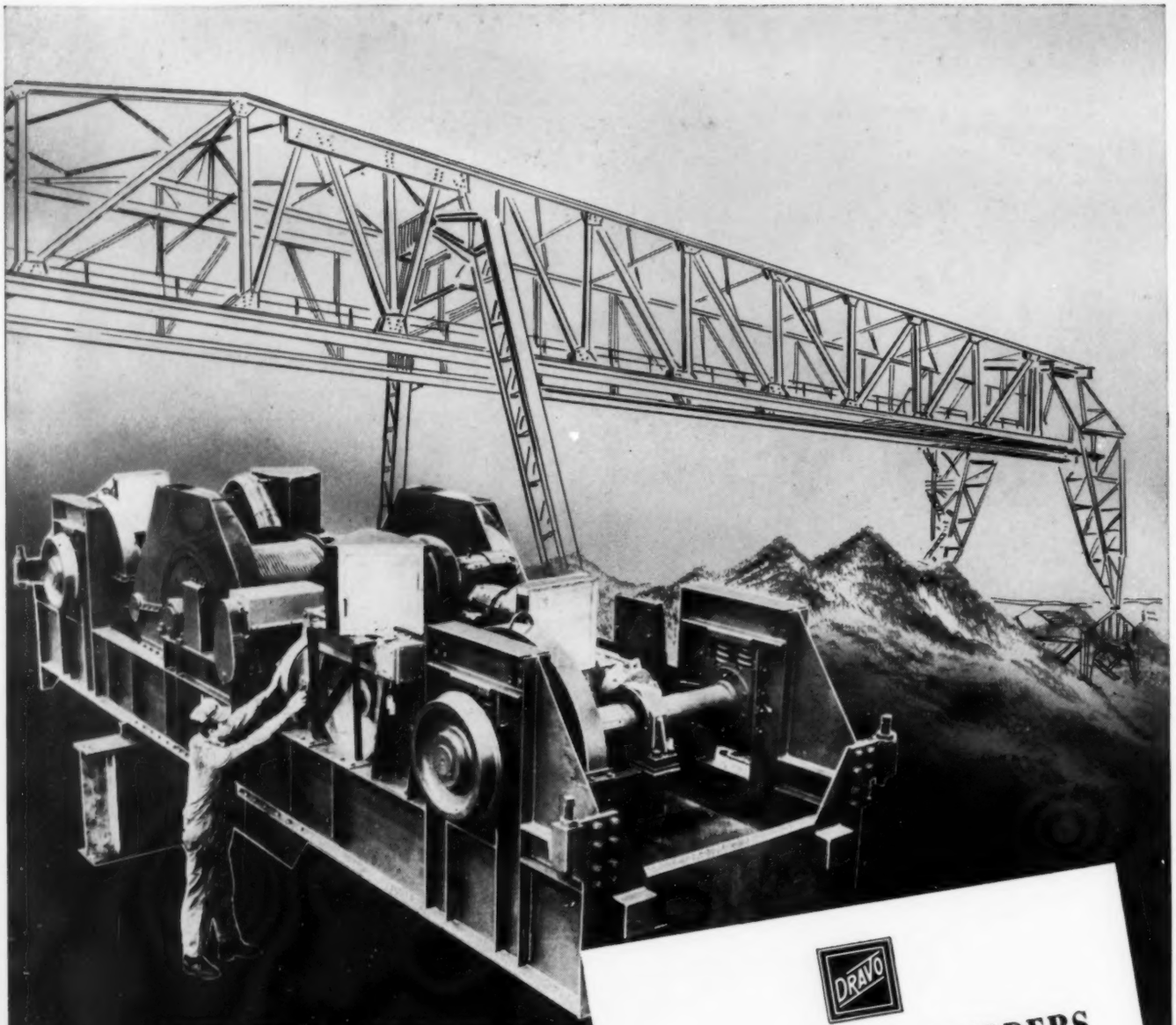

NORTH WESTERN-HANNA FUEL CO.'s unloading, stocking and reclaiming bridge has been modernized by the installation of a new 7½-ton man trolley, designed and fabricated by Dravo Corporation. Another trolley of this type was recently fabricated and installed by Dravo on a steel mill ore bridge.

Modernization such as this eliminates in many cases the need and expense of constructing a new bridge. New man trolleys improve existing bridge capacity and performance by providing faster and safer operating cycles.

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MODERNIZED TROLLEYS FOR EXISTING BRIDGES

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* SILVER BRAZING

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■ By many tests silver alloy brazing has been proved to make joints that are stronger than the metal parts being joined. It is used in Elliott motors and generators in all joints where permanence and the maximum conductivity of an enduring bond are essential. Below is shown the process of silver brazing the compensating winding joints in a large direct-current motor. The compensating winding—first developed by Elliott Ridgway Works in 1895—consists of copper bars insulated with mica, inserted in slots in the pole faces.

SHOWN AT LEFT is the completed Elliott 800 hp, 175/350 rpm, 600 volt D-C mill type motor with force ventilation covers and tachometer generator. This motor drives a Bliss reversing strip mill.

For full details on this and other Elliott motors, contact your local Elliott representative or write Elliott Company, Ridgway, Pa.

ELLIOTT Company

RIDGWAY DIVISION

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R2-14

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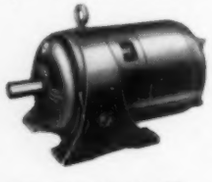
Maxi-Power Drives

Hygrade Drives



Foote Bros.-Louis Allis Gearmotors

Foote Bros. Gear and Machine Corporation
Dept. IAS, 4545 South Western Boulevard
Chicago 9, Illinois

Please send me a copy of Bulletin LPB on Foote Bros. Line-O-Power Drives.

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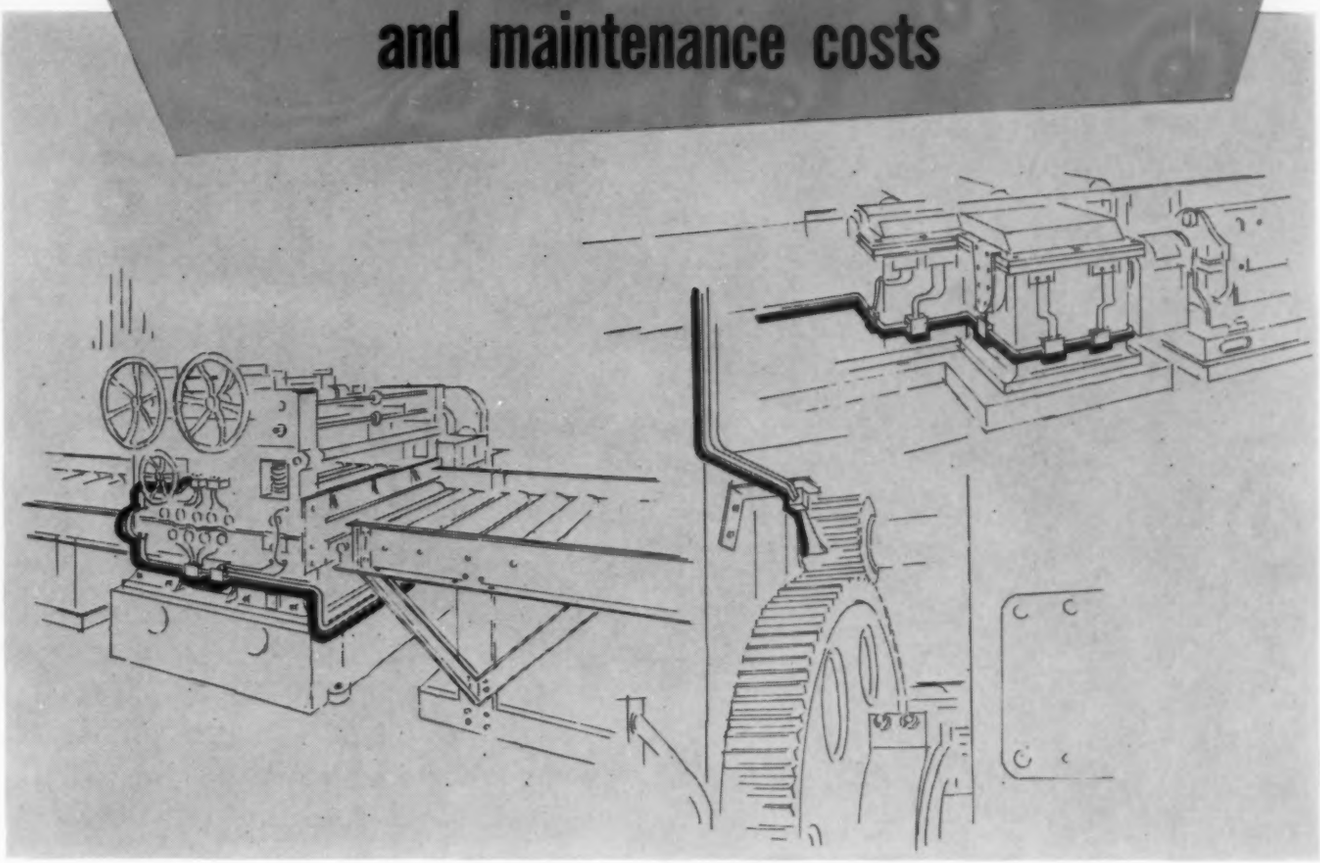
NUMBER 3 OF A SERIES

How Gulf Periodic Consultation Service helps rolling mills cut lubrication and maintenance costs



Application methods surveyed, improvements recommended

You'll find that Gulf Sales and Staff Engineers do more than simply recommend the proper oils and greases for your equipment. They offer help on every phase of lubrication, on every type of equipment.

When they initially survey your machinery, for example, they keep an experienced eye on the suitability of various applicators and systems which supply the oils and greases. The chances are good that some of this equipment in your plant could and should be improved.

For example, how much hand oiling is done? How is grease applied, at what intervals, and to how many individual points? You may benefit from the installation of more efficient methods of application.

For additional information, call in a Gulf Sales Engineer or send the coupon below.

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Please send me, without obligation, a copy of the booklet "Gulf Periodic Consultation Service."

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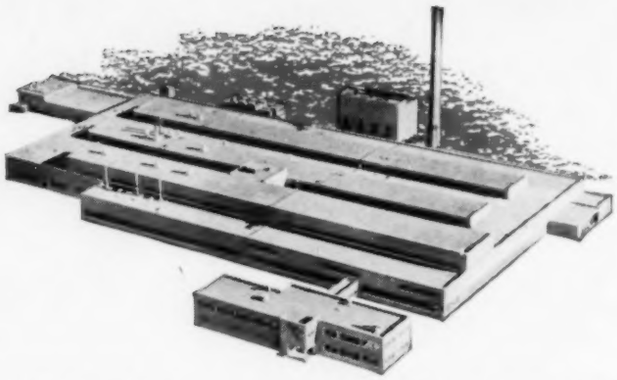

N-B-M Meadville . . . where the welcome mat is out. We're proud of this plant—its equipment and the skilled people who work in it. Proud enough, in fact, to offer a standing invitation to Blast Furnace Superintendents or other steel mill officials to visit us. When can *you* make an inspection trip?

These Bosh Plates take it standing up

Here's where you'll find *vertical* molding of copper castings . . . resulting in cleaner metal throughout.

Another reason why N-B-M Meadville is a name to remember when you specify copper castings. During 75 years of foundry experience, you learn many answers to better methods of production . . . methods that *improve casting quality and soundness.*

At N-B-M Meadville, one of these quality-improving production methods is *vertical molding*—eliminating chaplets. We've found—both by test and on-the-job experience—that vertical molding means uniformly higher quality. Any N-B-M Representative will welcome the chance to describe this unique method to you.

From the molding floor to the shipping room, N-B-M Meadville accomplishes what should be, and is, the main objective of this modern, well-manned plant . . . ***what you specify . . . we ship.***

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personal contact . . .

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Sept. 30, Oct. 1, 2 and 3

Here is an easy equation—
HAGAN Ring Balance Meters = Dependability

WITH Hagan Ring Balance Meters you get accurate flow integration on oxygen, water, steam, gas, oil or other fluids. You get a meter that is rugged and sturdy, but still a precision instrument throughout. Design is simple and maintenance costs are low.

HAGAN RING BALANCE FLOW METERS are the most versatile meters available. A single meter unit can indicate, record, and integrate one or two flow rates. Standard modifications provide for pressure and temperature compensation. Ring assemblies are available which are capable of measuring differentials from 1" to 420" water column maximum and for static pressures ranging up to 15,000 psig.

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For more information on how dependable Hagan Ring Balance Flow Meters can answer your metering problems, clip the coupon, or write, wire or call Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

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Hagan Building
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Carbon Steel

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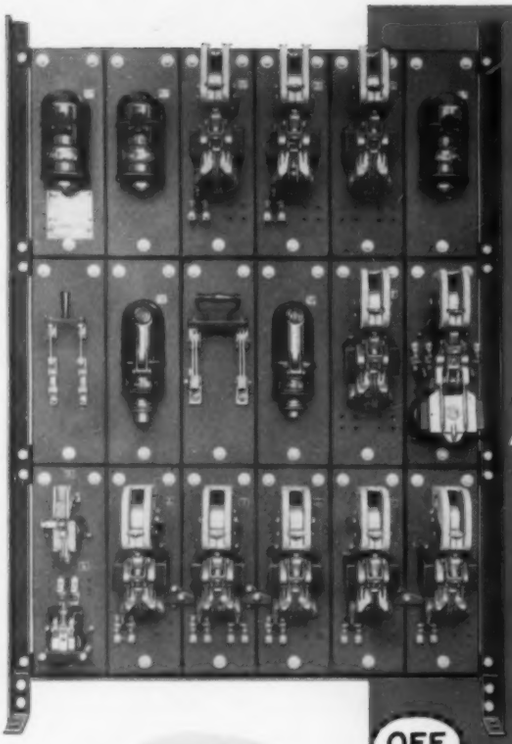

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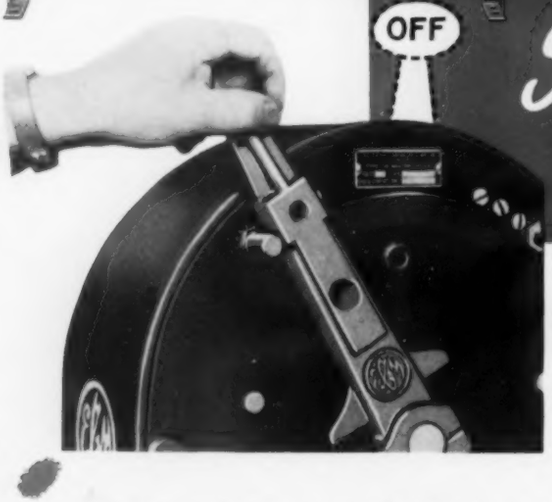
1 LINE-ARC Contactors
2 TIME-CURRENT Acceleration (D-c)
3 FREQUENCY RELAY Acceleration (A-c)
4 WRIGHT CIRCUIT Hoist Control (D-c)
5 YOUNGSTOWN Hoist Limit Stops
6 TYPE WB Brakes
7 CAM Master Switches
8 MANUAL-MAGNETIC Disconnect Switches
9 CONTRA-TORQUE Hoist Control (A-c)
10 TAB-WELD Resistors

These FUNCTIONAL NAMES Speak for Themselves

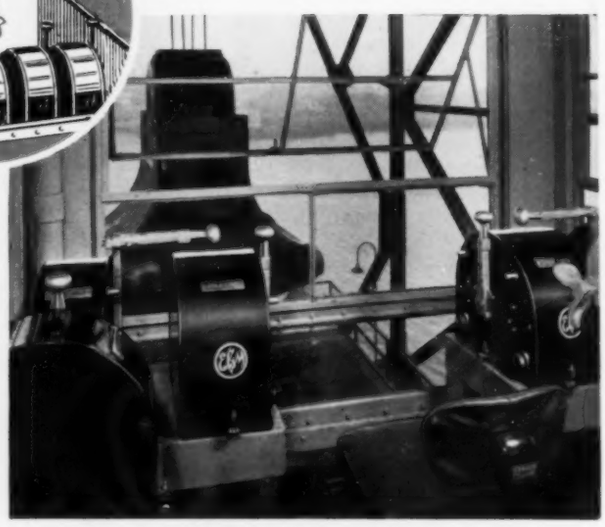
CAM Master Switches *for speed control*

Short Throw, Less Tiring

easier manipulation speeds output

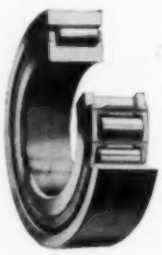


Ever popular with operators, EC&M *short-throw* Cam Master Switches have many features which make manipulation easy and result in improved operation. These are: Notching arrangement consists of two rails and two rollers—makes each speed point distinct and "off-point" easy to find. End-play clearance at neutral position gives a "lift" for quick inching between off and first points. Counterweight below main shaft offsets weight of operating arm—maintains speed point selected and prevents self-advance of the arm if the master switch is jarred or bumped. Overlapping cover excludes exterior dust. Large diameter cams speed opening and closing of coin–silver contacts. Many of these CAM Master Switches can be closely grouped because of their narrow width. For smooth, easy manipulation, specify EC&M CAM Master Switches.



Operator's Cab of new Ore Unloader with EC&M CAM Master Switches.

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO



good follow through...

Selecting the right type of bearing for your application is only the beginning of the job.

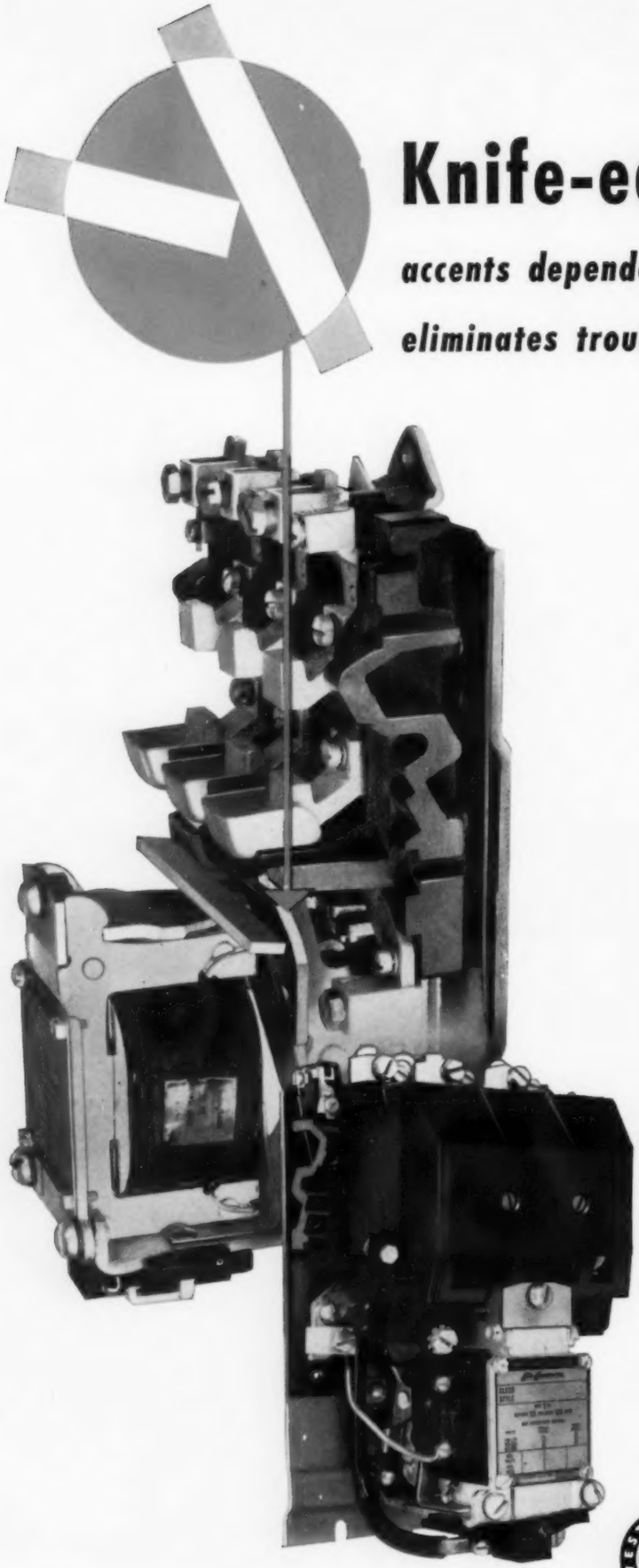
Torrington follows through to be sure the bearings are giving complete satisfaction. This is an important part of the *complete* bearing service Torrington gives to its customers.

Whether your problem is in the selection or operation of anti-friction bearings, we will be happy to work with you. Send us the details of your application today.

THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Conn.
District Offices and Distributors in Principal Cities of the United States and Canada

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Straight Roller • Needle • Ball • Needle Rollers



Knife-edge Action . . .

accents dependability

eliminates trouble

in A-C "NR Contactors"

Long, trouble-free, dependable service . . . with Westinghouse NR Contactors!

Here you have a contact closing arrangement designed with fewer moving parts! The entire contact assembly pivots on a knife-edge of specially hardened steel. As a result . . . no sliding surfaces to bind or wear . . . no misalignment troubles. Friction is at a minimum! Jamming and sticking are eliminated! Nothing need be lubricated!

NR Contactors perform accurately. Positive-action, kick-out springs give sure contact openings—independent of gravity. You've got full protection against false operation from vibration or accidental impact.

The contact is double break, spring loaded, tipped with silver . . . which means constant high conductivity . . . no need for filing, dressing or cleaning. Westinghouse-developed "De-ion®" Arc Chamber snuffs out the arc in half cycle or less, thereby minimizing contact damage.

Yes, you get superior performance for any contactor application with Westinghouse NR Contactors.

Learn many other features and the performance story of these NR Contactors by asking your Westinghouse representative or writing directly to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21678

YOU CAN BE SURE... IF IT'S Westinghouse

CONTROLS

UNITED

6 stand continuous horizontal

and vertical Billet Mill

UNITED ENGINEERING AND FOUNDRY COMPANY

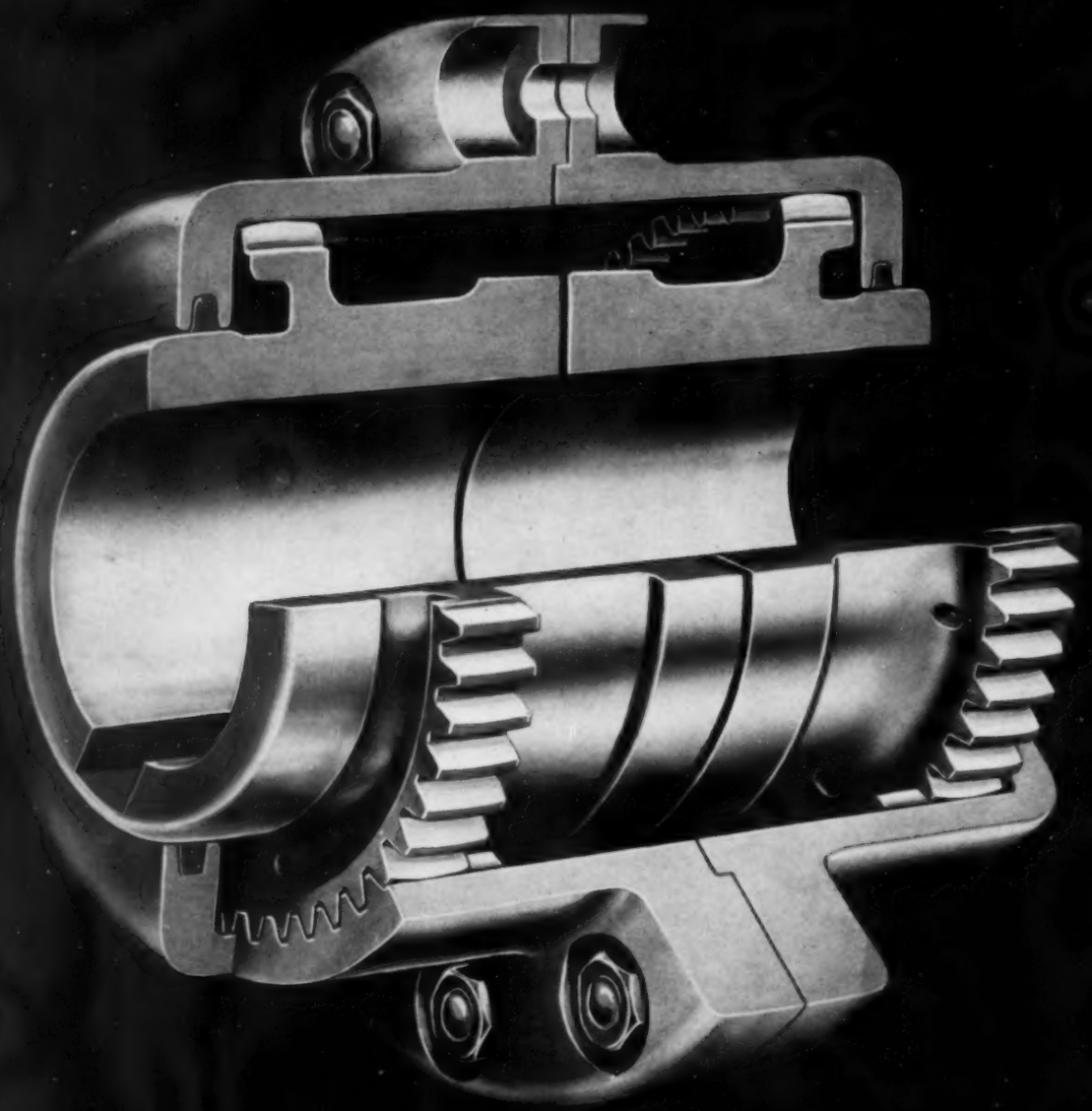
Pittsburgh, Pennsylvania

PLANTS AT PITTSBURGH • VANDERGRIFT • NEW CASTLE
YOUNGSTOWN • CANTON

SUBSIDIARIES: ADAMSON UNITED COMPANY, AKRON, OHIO
LOBDELL UNITED COMPANY, WILMINGTON, DELAWARE
STEDMAN FOUNDRY AND MACHINE CO., INC., AURORA, INDIANA

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery. Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments.

POOLE

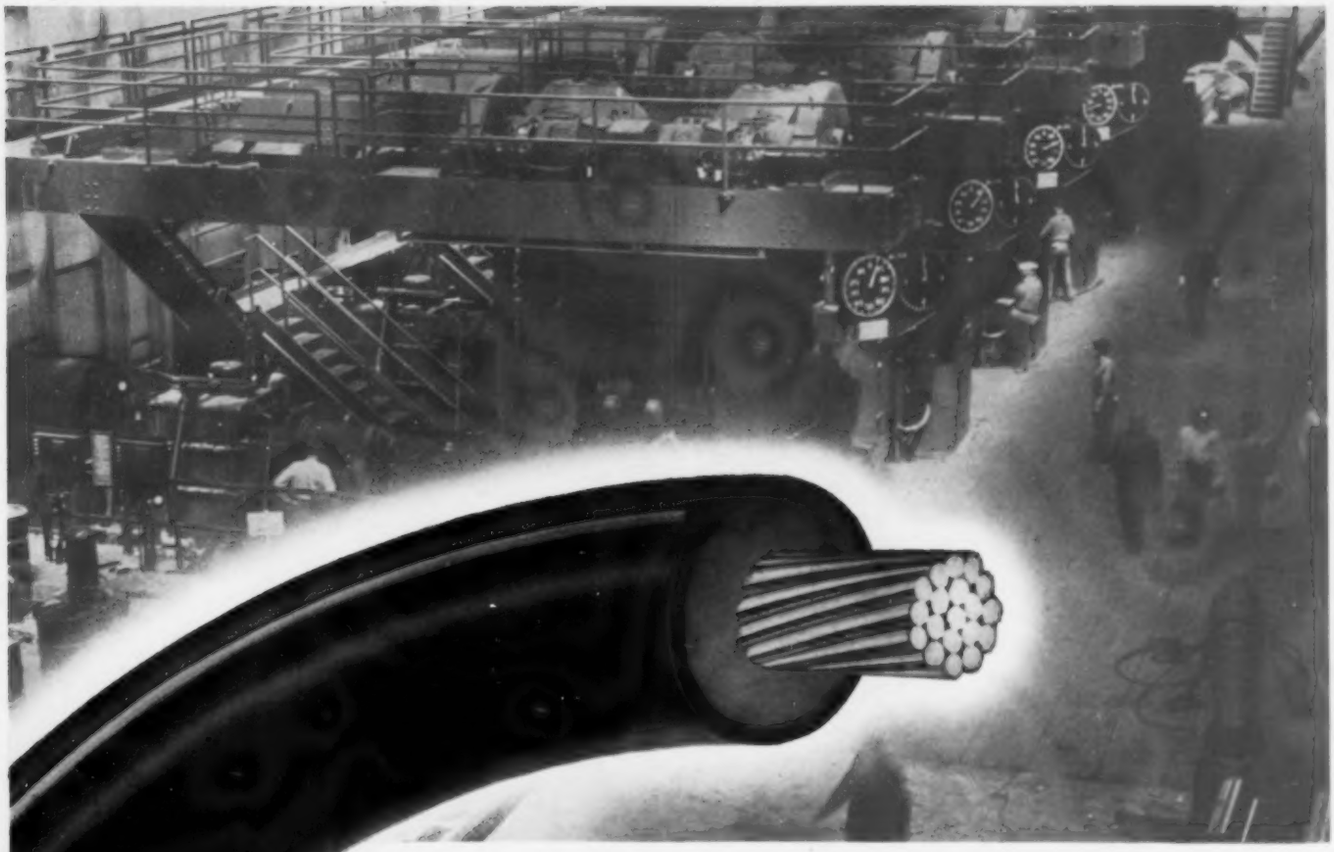


A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.



CUT OUTAGE TIME ALL ALONG THE LINE

with OKOLITE-OKOPRENE electrical cables

Steel mill conditions are rough on electrical cables. Heat, flame, moisture, dirt, mechanical damage, corrosive fumes—the life of an electrical cable is a continual fight against such elements. Electrical men in the steel industry reduce outages due to such conditions with Okolite-Okoprene cables.

Okolite-Okoprene is particularly suitable for use in steel mills because of the exceptional properties of its electrical insulation and protective sheath.

Okolite insulation, itself resistant to heat and moisture, is highly reliable under the continuous heavy usage characteristic of steel mills. Okolite has proved itself by a long record of trouble-free operation under severe service conditions.

Okoprene protective sheath is compounded from an exclusive Okonite formulation, the basis of which is neoprene. It contains no rubber. When exposed to most acids, alkalies, chemicals, oils and moisture, it will outperform any other common type of cable covering such as lead or braid.

Okonite's famous strip process, for applying insulation and sheath simultaneously, adds still greater endurance to the cable. Conductors are perfectly centered, and both sheath and insulation are uniformly vulcanized to give higher mechanical and electrical properties of lasting quality.

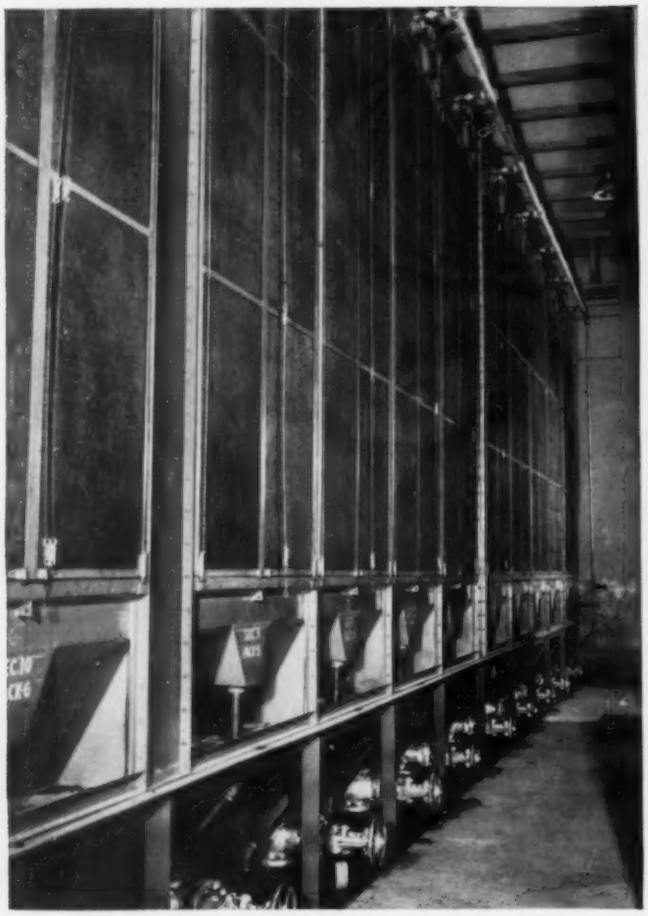
Bulletin IS-1053 gives convincing facts on the stability and performance of Okolite-Okoprene. Write for it today to The Okonite Company, Passaic, N. J.

The best cable is your best policy

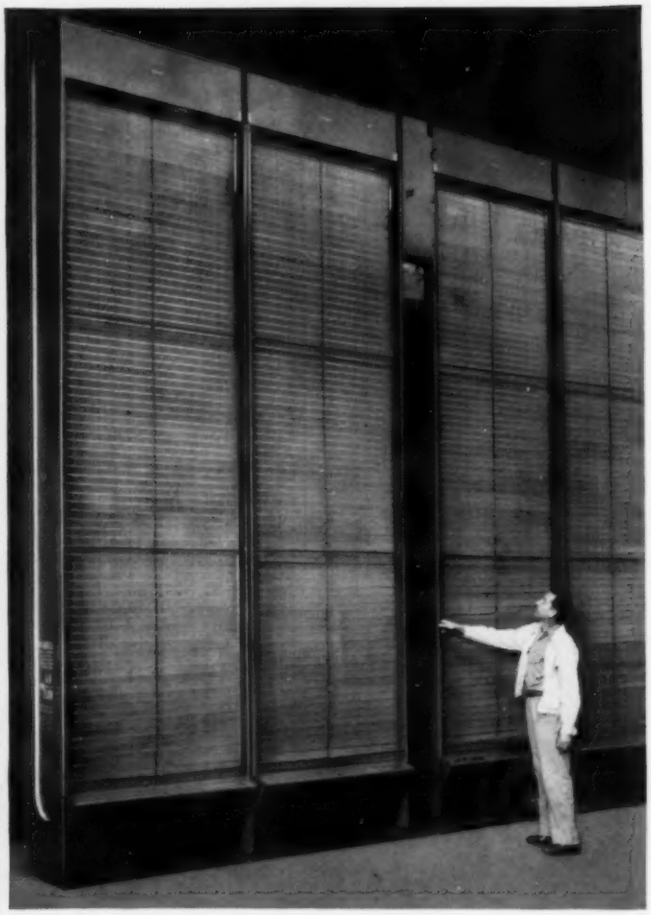
OKONITE OKONITE SINCE 1878 *insulated wires and cables*

9804

clean air costs less than dust!



A bank of AAF ELECTRO-MATICS in service at Weirton Steel Company. Fully-automatic and self-cleaning, these electronic precipitators require minimum maintenance.



Developed specially for the steel industry in 1928 by American Air Filter, the MULTI-DUTY features overlapping panel construction. Photo above shows latest model.

AAF offers two proved units for mill motor rooms

Two good reasons why more and more steel mills are specifying AAF air-cleaning equipment are the ELECTRO-MATIC precipitator and the MULTI-DUTY air filter. Thousands of these proved units are now in service throughout the country. Their day by day performance cuts maintenance costs, reduces costly shutdowns and increases general operating efficiency. Mill motors last longer when these air-cleaners are on hand.

ELECTRO-MATIC—The only automatic electronic precipitator—an exclusive development of AAF engineering and research combining the advantages of electronic air-cleaning and automatic operation.

MULTI-DUTY — The most widely-used automatic air filter — employs an overlapping panel construction of exclusive design. This results in high cleaning efficiency and positive self-cleaning of the filter elements to maintain uniform air delivery.

For complete engineering data on AAF equipment contact your nearest American Air Filter representative . . . or write for "Composite Catalog"—Bulletin No. 510, American Air Filter Company, Inc., 302 Central Avenue, Louisville 8, Kentucky.

AAF

American Air Filter

COMPANY, INC.

302 Central Avenue, Louisville 8, Kentucky

American Air Filter of Canada, Ltd., Montreal, P. Q. • Pacific Division Office, San Francisco, Cal.

What's the $ Connection?

If there's a furnace operation in your setup . . . there's a mighty big connection between the CITIES SERVICE HEAT PROVER and your profit and loss picture.

Heat Prover—not an instrument you buy, but a service we supply—helps to increase furnace productivity through these five unique advantages:

1. **Rapid, continuous sampling.**
2. **Simultaneous reading of oxygen and combustibles.**
3. **Direct measurement of oxygen and combustibles.**
4. **Easy portability.**
5. **No maintenance; no re-calibration.**

ACCURATE, FAST CITIES SERVICE HEAT PROVER ANALYSIS CAN PUT THE FINGER ON WASTE IN YOUR FURNACE OPERATION. It's being widely used in a great variety of industries. Find out how Heat Prover can serve you. Write Cities Service Oil Company, Dept. H17, Sixty Wall Tower, New York City 5.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Nearing

WORLD'S LARGEST CRUSHERS are two 3500-tph, 60-109 *Superior* gyratories being built for Mesabi's first commercial taconite plant. Ultimate plant output will be 10 million tons.

FINES ARE SCALPED from r.o.m. ore on sturdy 1000-tph vibrating screens like this one in Minnesota. A-C builds *six* separate types of vibrating screens for beneficiation.

EQUIPMENT FOR IRON ORE BENEFICIATION: Gyratory and jaw crushers . . . Vibrating screens . . . All types of washers . . . Concentrating jigs . . . Rod, ball, and *Ballpeb* mills . . . Centrifugal pumps . . . Rotary kilns and coolers . . . *Texrope* V-belt drives . . . All types and sizes of electric motors and generators . . . Starters . . . Transformers and voltage regulators . . . Complete power generation, distribution, control equipment.

the Bottom!

As Mesabi Ores Lean Out, Allis-Chalmers Aids in Beneficiation

DIRECT SHIPPING ORES are fading fast up on the once fabulous Mesabi range. But despite foreign ore discoveries, by 1955 a quarter of blast furnace feed must be beneficiated domestic ore.

Allis-Chalmers — manufacturer of equipment for the steel industry from the mine to the mill — is helping lead the way to more economical beneficiation of lean ores.

Does low ore content require you to triple material handled? Allis-Chalmers will build you bigger, more efficient equipment! At far left below is the world's largest crusher, being built by A-C for a Mesabi taconite plant.

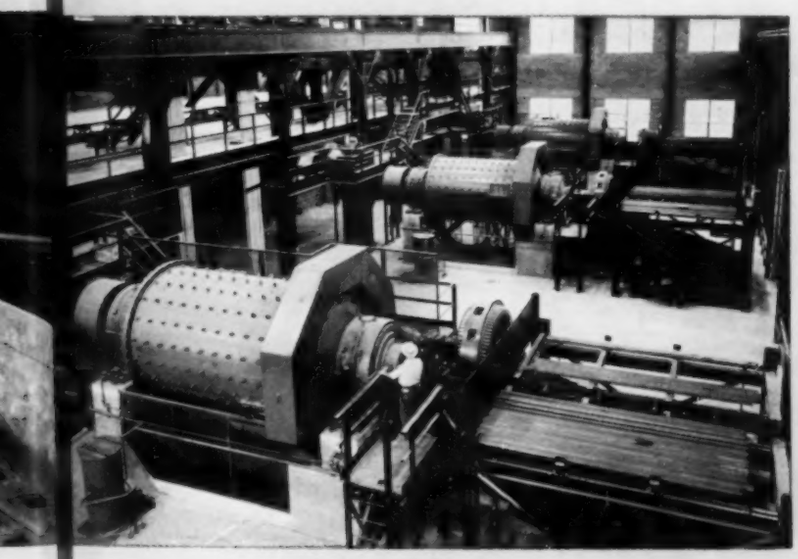
Has proper yet economical pelletizing got you stumped? Allis-Chalmers has just put into operation a pilot Pelletizing and Heat Hardening plant built exclusively for researching new pelletizing methods.

Do you have a beneficiation "shortcut" in mind? Don't let lack of equipment postpone your testing of new processes. The Allis-Chalmers Processing Research Laboratory stands ready to accurately and exhaustively test any processing method on a confidential basis.

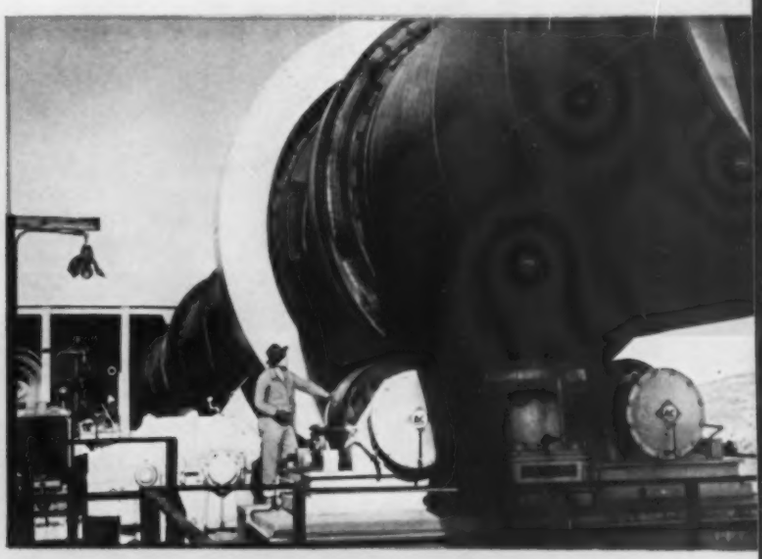
For over half a century Allis-Chalmers equipment has been processing ores for America's steel industry. Some of the cost-cutting, tonnage-increasing ore beneficiation equipment in the broad A-C line is seen on these pages.

Allis-Chalmers offers you *one-manufacturer responsibility* for process, drive and control equipment all along your flow sheet. For literature or detailed information on products and services, call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-3808

Superior, Ballpeb and Texrope are Allis-Chalmers trademarks.



ORE IS GROUND in three rod and ball mills ahead of magnetic separation at this beneficiation plant. A-C builds *all* types of grinding mills for ore beneficiation processes.

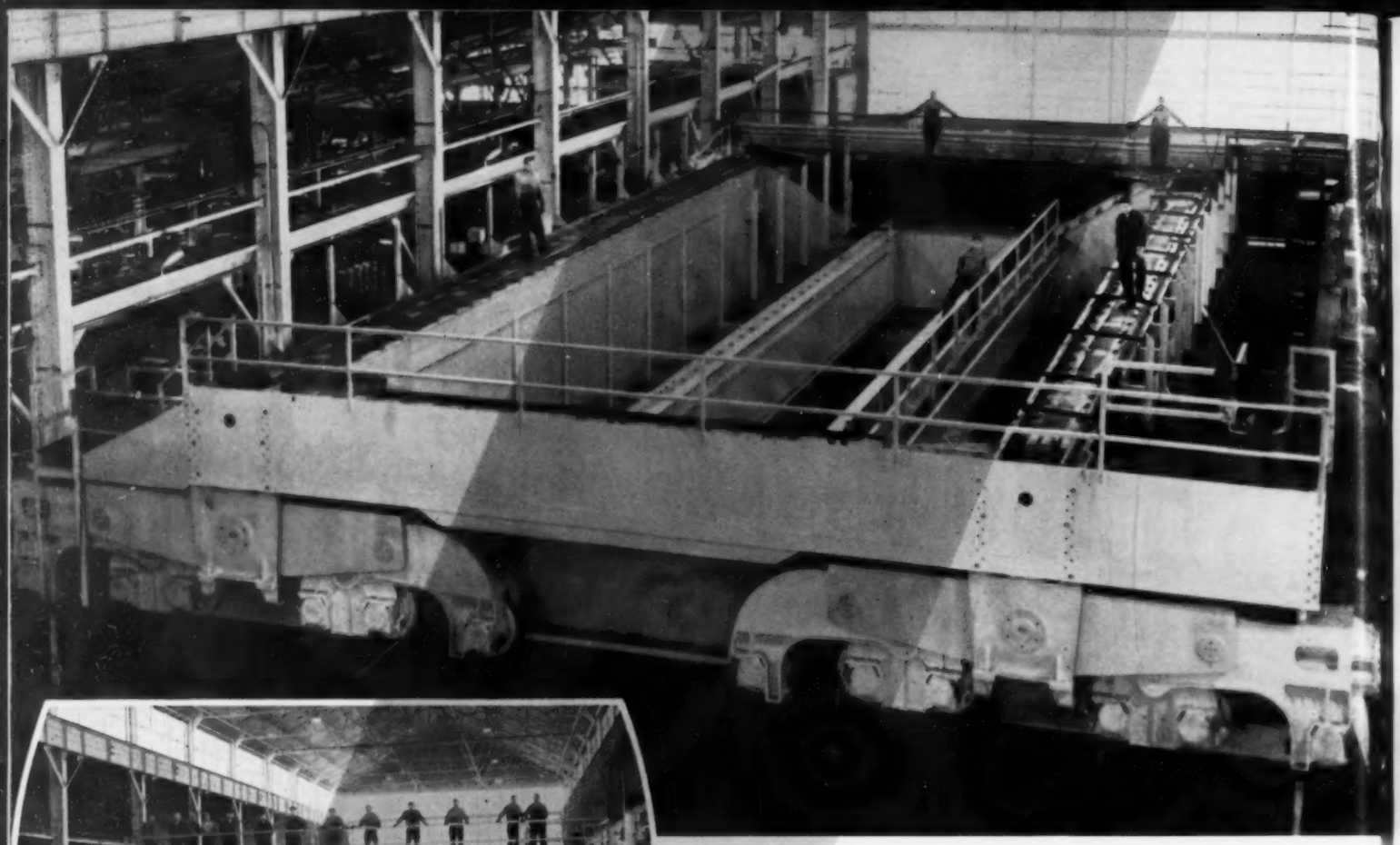


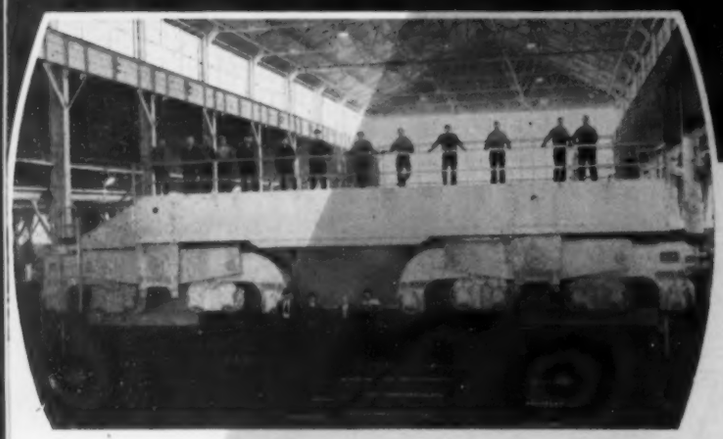
IRON ORE IS AGGLOMERATED to make good blast furnace and open hearth feed in Allis-Chalmers rotary kilns in connection with iron mines and beneficiation plants.

ALLIS-CHALMERS

A-C ALLIS CHALMERS

Power, Electrical, Processing Equipment for Iron and Steel





BRIDGE SPAN 76 FEET, OVERALL WIDTH 60 FEET

world's biggest ladle crane gets final inspection . . . . it's 350/60/25 TON ALLIANCE BUILT

● You're looking at two pictures of the world's largest ladle crane, shown, during final assembly, on the erection floor of the Alliance Machine Company.

This 350/60/25-ton, 4-girder, vibration-free giant will soon be helping one of the world's largest steel producers increase production capacity.

It's equipped with 24 track wheels on the bridge. The crane is so designed that each track wheel bears exactly 1/24th of the total load. And, like all Alliance Cranes, built for handling hot metals, raw materials, and finished products, it's safer, easier to operate and many times more efficient.

even bigger model now being built

The never-ending demand for bigger, better lifting power has kept Alliance on a constant path of research and development. For more than 50 years, Alliance has been the world's largest producer of the world's largest cranes.

Now in production are three 450-ton, 4-girder Alliance ladle cranes. These will be the largest ladle cranes ever built.

Let Alliance engineers help you with your heavy material handling problems. Write us today for an early consultation.

THE *Alliance* **MACHINE COMPANY**

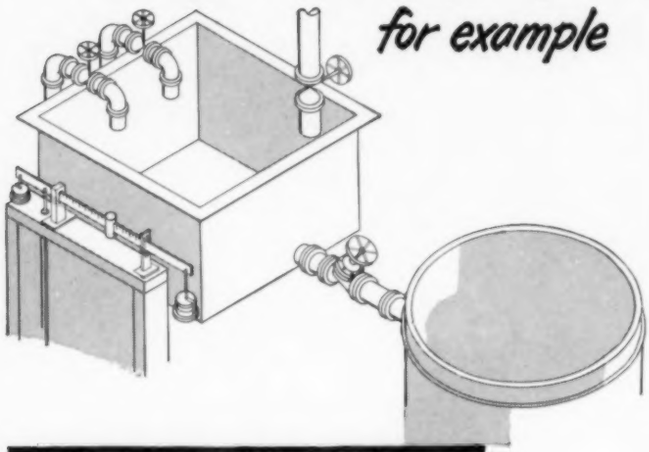
World's largest builders of world's largest cranes

MAIN OFFICE
ALLIANCE, OHIO • PITTSBURGH OFFICE
1622 OLIVER BUILDING, PITTSBURGH, PA.

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

Found: This Good Alternate for Alloy Valves

on chrome tanning liquor, for example



THE INSTALLATION

At Gutmann & Co., tannery, Chicago, on outlet of open scale tank for mixing highly corrosive basic sulphate of chrome solution used in tanning.

THE HISTORY

This plant had more than its share of trouble with various valves and cocks tried in this service. The highly corrosive solution caused rapid seat wear, leakage, seizing, and constant stuffing box maintenance was necessary. The inoperative valves, and shut-downs for repairs played havoc with the daily schedule of solution mixing.

All this trouble has stopped since the plant installed a Crane No. 1615 Iron Body Packless Diaphragm valve with Neoprene diaphragm, disc insert, and body lining. Even after 2½ years in this severe service, the valve remains absolutely tight; shows no corrosive or erosive effects, no undue mechanical wear, and operates as smoothly as when new. Maintenance cost to date—zero.

VALVE SERVICE RATINGS

SUITABILITY: Neoprene lining good

MAINTENANCE COST: None - inspection only

CORROSION-RESISTANCE: O.K. - no corrosion showing

SERVICE LIFE: In 2½ years - still like new

OPERATING RESULTS: No fluid loss - no valve trouble - no production loss

PRICE: Lower than expected

AVAILABILITY: Regular Crane item

THE VALVE

Crane No. 1615 Packless Diaphragm Valves with Neoprene Lining. Diaphragm acts as bonnet seal only; is not subject to rapid wear. Separate disc with Neoprene insert shuts off flow even should diaphragm fail. Neoprene body lining makes these valves highly suitable for many corrosive fluids, erosive sludges and slurries. Also available unlined. See your Crane Catalog or Crane Representative.

The Complete Crane Line Meets All Valve Needs. That's Why,

More Crane Valves Are Used Than Any Other Make!

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois

Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

BUILT FOR TODAY'S GREATER POWER NEEDS

THE IMPROVED Exide-Ironclad BATTERY

for battery-electric trucks of all types, sizes and makes

IT'S OUTSTANDING... in design, performance, length of life. Back of the improved Exide-Ironclad battery are years of progressive research-engineering that have developed a continuous flow of improvements. *Now comes another great advancement*...

A NEW and EXCLUSIVE FEATURE—the polyethylene insulating tube sealer. This and other major improvements combine to make Exide-Ironclad, *more than ever before*, YOUR BEST POWER BUY ... AT ANY PRICE.

BUILT TO GIVE YOU...

RAPID ACCURATE HANDLING... UNIFORM RATE OF HANDLING... HIGH AVAILABILITY... LOW OPERATING COSTS ... LOW MAINTENANCE COSTS... LOW DEPRECIATION COSTS... HIGH MANEUVERABILITY... SAFE HANDLING

BECAUSE OF...

IMPROVED POSITIVE PLATE CONSTRUCTION

... the long-life grids now contain SILVIUM—an alloy of silver, lead and other components—which make them highly corrosion resistant. Top conducting bar is heavier.

...with the New Polyethylene insulating tube sealer

An insulating sealer for the bottom of the tubes. Acid-proof, non-corroding plastic, it fits snugly into slotted tubes of positive plate, and reduces loss of active material. Even the small sediment deposit of the past is reduced 50%. Thus, more active material remains available, and the high battery capacity is sustained for longer working life.

PERMANIZED NEGATIVE PLATES

Improved processing, a result of Exide Quality Control assures uniform plates with higher electrical efficiency. These negatives, teamed with the improved positive plates, give you a well-balanced combination for hard service and long life.

NEW SEALING COMPOUND

Through the cooperative efforts of Exide Laboratories and the Franklin Institute, a new homogeneous compound was developed. It makes a permanent seal between the jar and cover, resisting shock without cracking in high or low temperatures.

SEAMLESS SHOCK-PROOF JAR

Made of high quality rubber. A scientifically selected combination of tensile strength and elongation provides a sturdy jar built for long life and heavy-duty service.

CORROSION RESISTANT TRAY GUARD

A plastic acid-resistant steel tray coating with high insulating quality and ability to withstand hard knocks.

NEW UNBREAKABLE PLASTIC VENT PLUGS

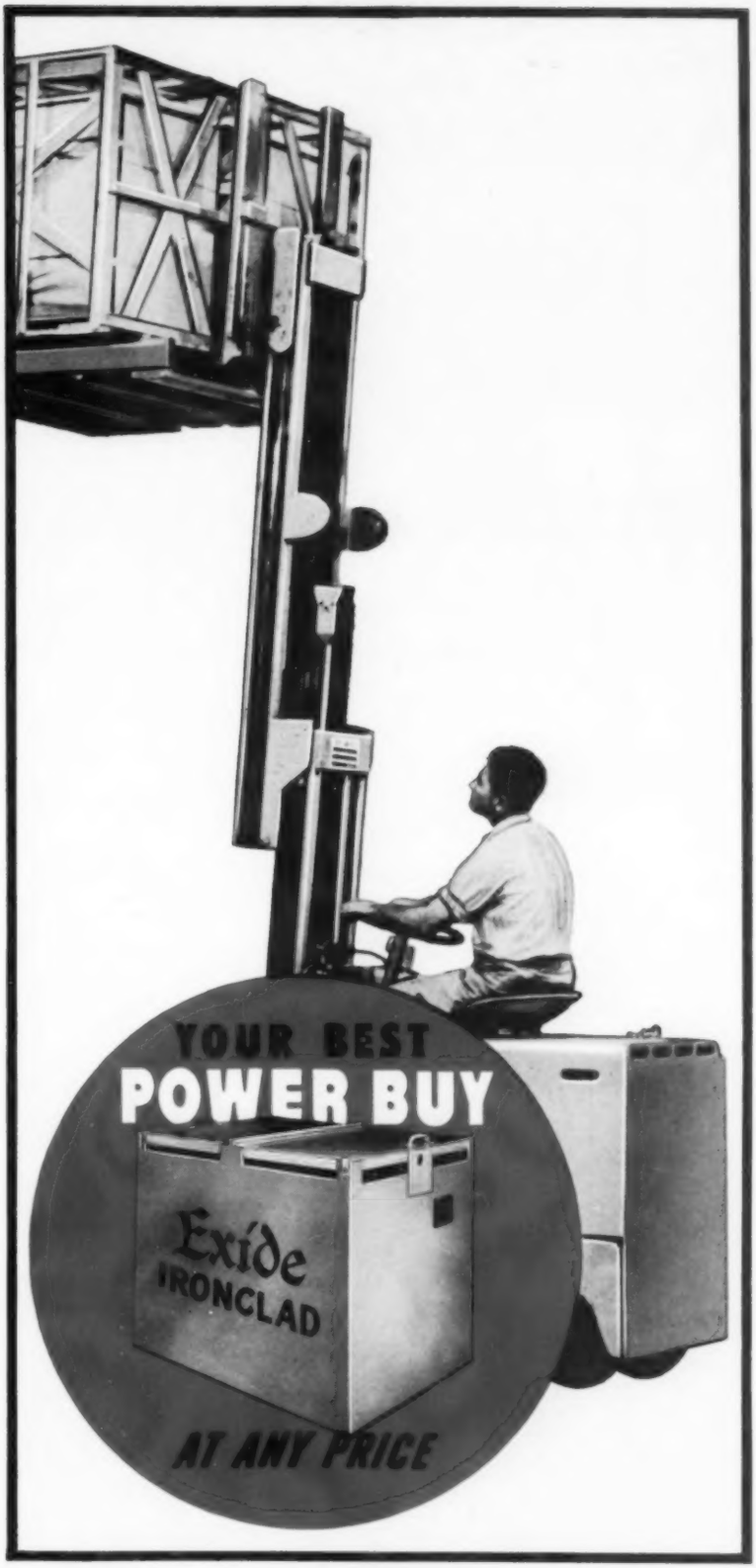
Made of unbreakable polyethylene. Can be quickly and easily removed to add water.

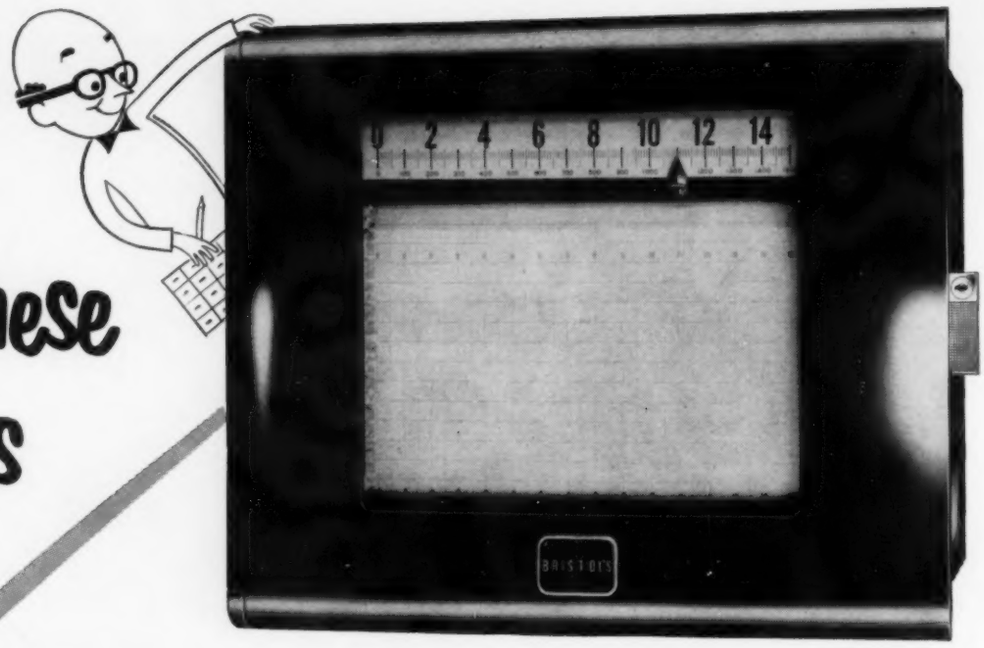
Types and sizes for storage battery applications in all heavy-duty services.

Write today for further information.

THE ELECTRIC STORAGE BATTERY CO.
Philadelphia 2
Exide Batteries of Canada, Limited, Toronto

EXIDE-IRONCLAD and "PERMANIZED" *Reg. Trade-marks U. S. Pat. Off.* "SILVIUM" *T. M. Reg. applied for*





Check these features OF THE BRISTOL DYNAMASTER

—the electronic master-mind for your temperature measuring, recording and controlling problems

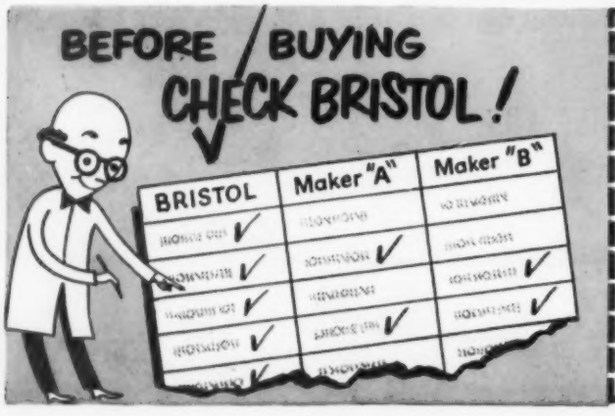
- ✓ Continuous-balancing electronic circuit responds instantly to minute changes
- ✓ All types of electric and air-operated controllers offered
- ✓ Available as a self-balancing bridge or potentiometer
- ✓ Trouble-free operation
- ✓ Electronic component uses vacuum tubes available at any radio supply house
- ✓ Full-scale pen travel in 7, 3 or ⅓ seconds
- ✓ Chart speeds from ¾ in. per hour to 7200 in. per hour
- ✓ Multiple recorders up to 16 points
- ✓ Components interchangeable and easily replaced on all Dynamaster models
- ✓ Immune to most vibration or shock
- ✓ Exceptionally unaffected by stray currents (1000 to 1 discrimination).

BRISTOL

FOR DETAILED PROOF *of the sensitivity, versatility and reliability of the electronic Dynamaster, use the coupon or write for Catalog P1245.*

The dependable Guidepost of Industry

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



THE BRISTOL COMPANY
123 Bristol Road
BRISTOL, CONNECTICUT

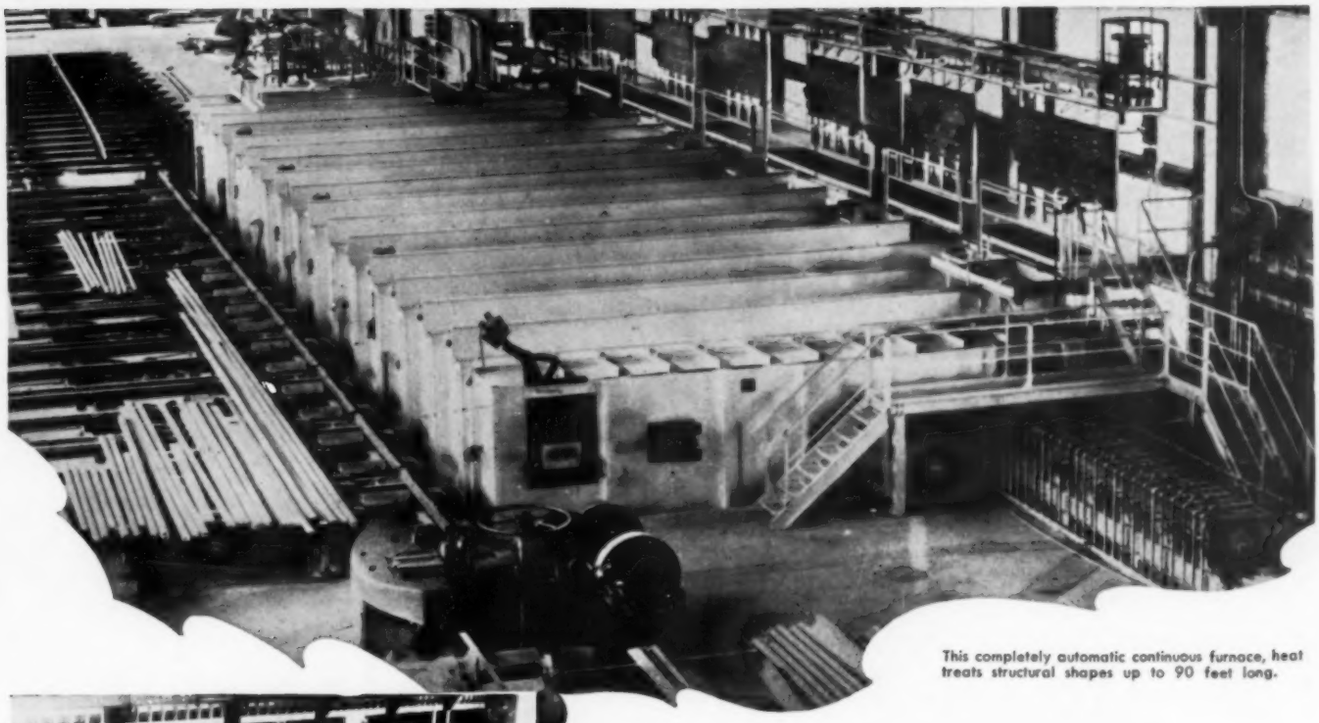
Please send catalog giving details of Dynamaster performance to:

NAME _____ TITLE _____

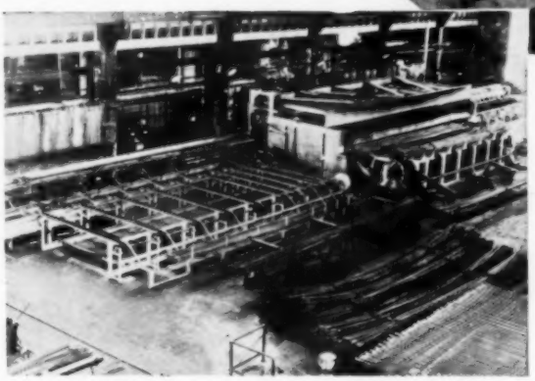
COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____



This completely automatic continuous furnace, heat treats structural shapes up to 90 feet long.



An EF gas fired heat treating furnace, quenching machine and rod straightener — handles rods up to 30 ft. in length, continuously.

A large capacity EF continuous strip normalizing, annealing and galvanizing unit. This combination gas fired radiant tube and electrically heated installation is over 400 feet long.

93 ft. Long x 26 ft. Wide Maintains Temperature ±5°

Because of its great number of successful, large and unusual furnace installations The Electric Furnace Co. has justly earned an enviable reputation for solving difficult production furnace problems.

The furnaces shown are typical examples — the large aluminum furnace above is completely automatic — large structural shapes up to 90 ft. in length are automatically charged into the furnace, carried across the heating chamber and discharged through a spray quench — everything is automatic.

The heating chamber is 93 ft long by 26 ft wide. Despite its size it maintains a uniform temperature throughout the entire heating chamber.

The furnace shown above at left is another outstanding installation — this equipment heats, quenches and straightens rods up to 30 ft. in length and was the first successful continuous furnace of this type built for this process. Several somewhat similar installations have since been made.

The view at left shows one of several large capacity continuous units we have built for processing ferrous and non-ferrous strip.

Other outstanding production furnace installations include furnaces for bright annealing both ferrous and non-ferrous strip, wire, tubing and other products... furnaces for the production heat treatment of tank armor castings, cartridge cases, shell forgings, bomb and gun parts, machine gun cartridge clips, aircraft and aircraft engine parts, aluminum and magnesium castings, bolts, springs, and many other products.

If you have a difficult production furnace problem put it up to our experienced engineers — no job is too large or too unusual.

We specialize in building *production* furnaces.

Gas-Fired, Oil-Fired EF and Electric Furnaces

for any Process, Product or Production

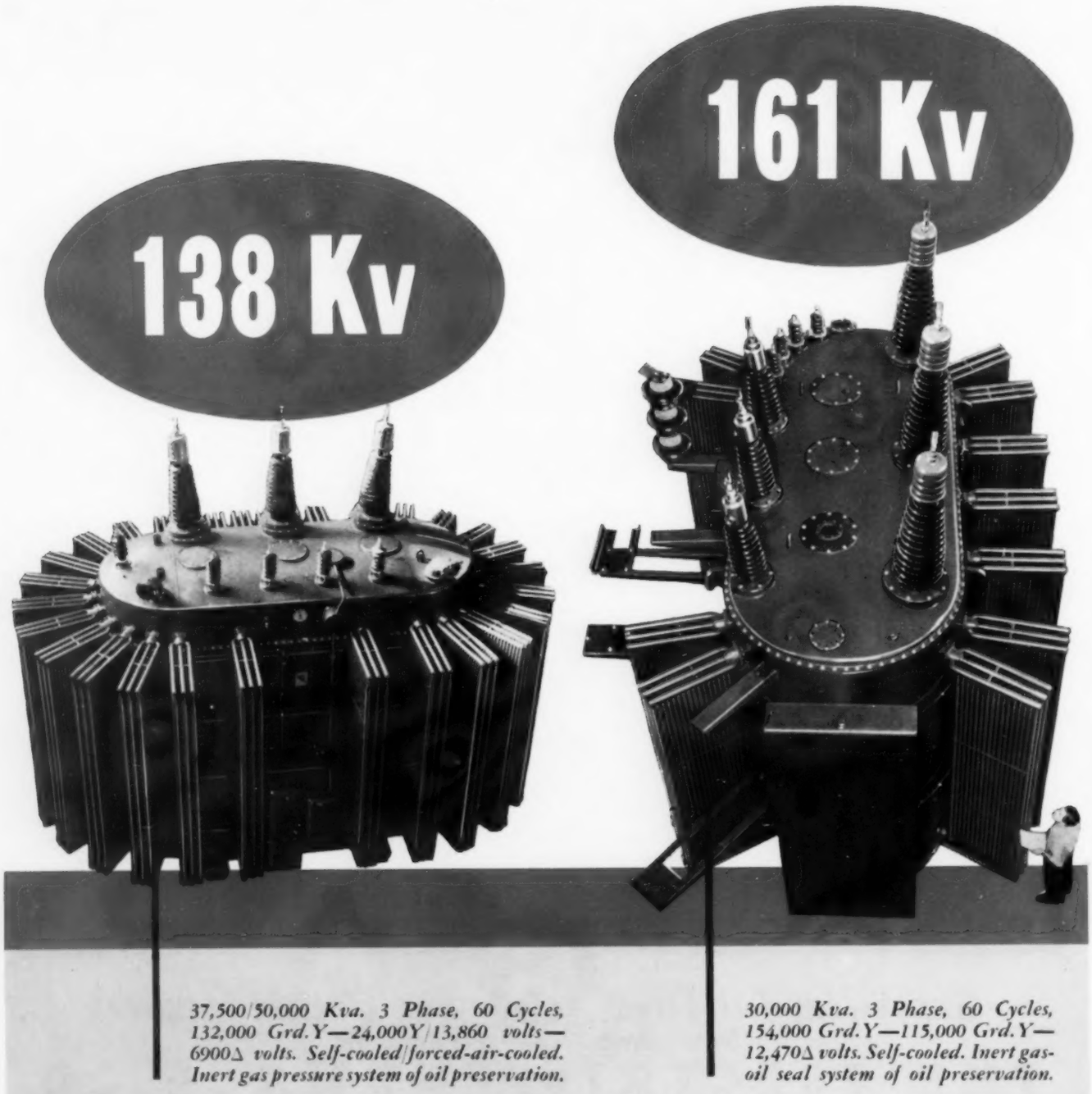
THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R. *Salem - Ohio*

High Voltage POWER

by

Pennsylvania



37,500/50,000 Kva. 3 Phase, 60 Cycles, 132,000 Grd. Y—24,000Y/13,860 volts—6900Δ volts. Self-cooled/forced-air-cooled. Inert gas pressure system of oil preservation.

30,000 Kva. 3 Phase, 60 Cycles, 154,000 Grd. Y—115,000 Grd. Y—12,470Δ volts. Self-cooled. Inert gas-oil seal system of oil preservation.

TRANSFORMERS

Typical of the many higher voltage power transformers now under construction in the Pennsylvania plant are the recently-completed units pictured here. They represent single and three-phase transformers of core-form and shell-form construction.

Each transformer is designed and manufactured with the extra care and precision which will pay dividends to the user in the form of outstanding reliability and low operating costs.

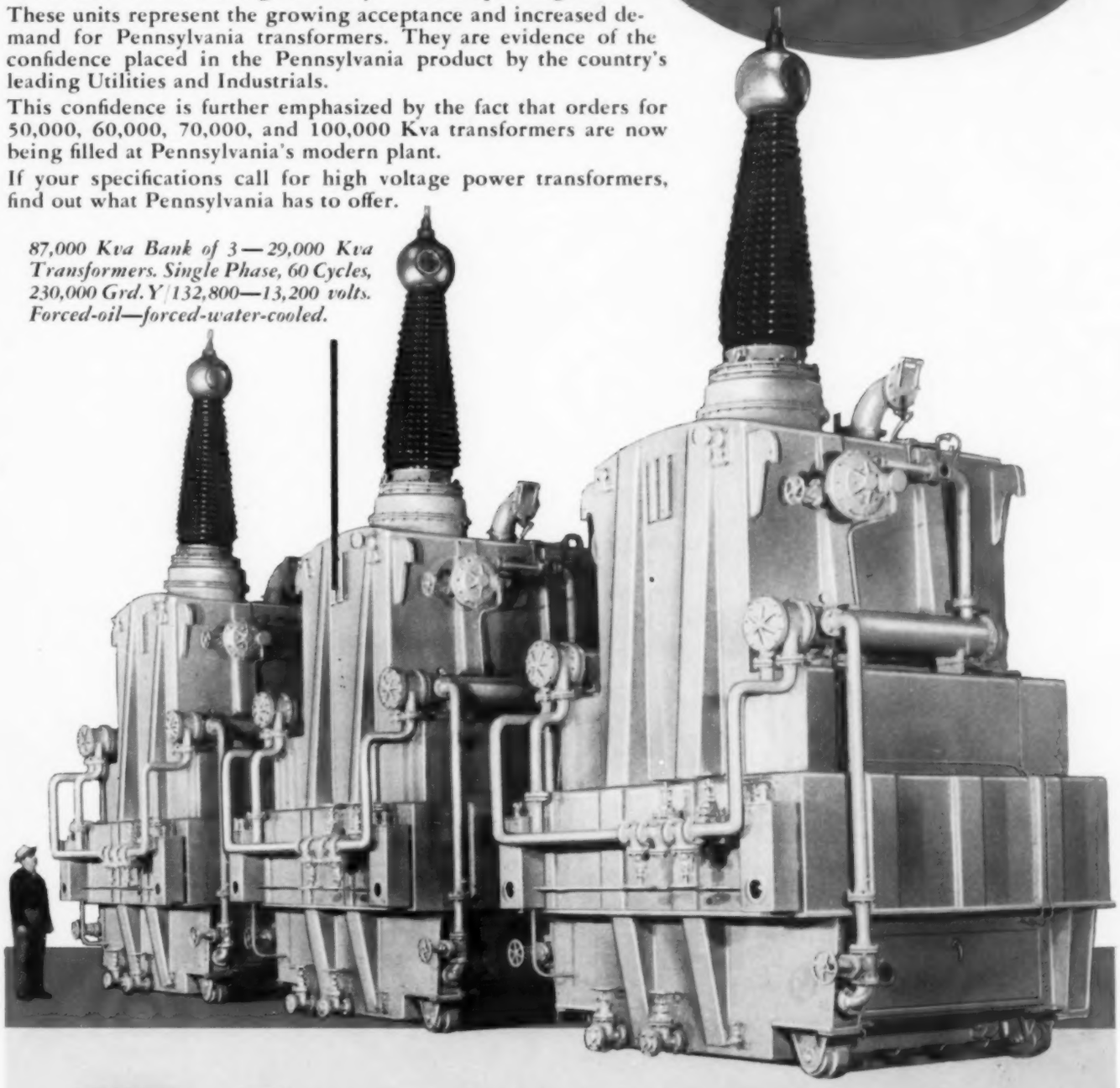
These units represent the growing acceptance and increased demand for Pennsylvania transformers. They are evidence of the confidence placed in the Pennsylvania product by the country's leading Utilities and Industrials.

This confidence is further emphasized by the fact that orders for 50,000, 60,000, 70,000, and 100,000 Kva transformers are now being filled at Pennsylvania's modern plant.

If your specifications call for high voltage power transformers, find out what Pennsylvania has to offer.

230 Kv

87,000 Kva Bank of 3—29,000 Kva Transformers. Single Phase, 60 Cycles, 230,000 Grd. Y/132,800—13,200 volts. Forced-oil—forced-water-cooled.



Pennsylvania TRANSFORMERS

Pennsylvania TRANSFORMER COMPANY

CANONSBURG, PENNA. • *Greater Pittsburgh District*

They did what you can do to produce more

Weirton's new tinning line is a three-high structure (background). The strip moves up through three decks where it's plated and washed. Reflow takes place as it descends the tower in back of Weirton department superintendent, Harry Reading, and tinplate manager, Al Kadell. Man in foreground runs the whole operation from his master control panel.

The world's fastest tinning lines

This new tinning line of Weirton's is one of the world's fastest. It operates at 2,500 fpm, three times faster than most lines. Yet product quality is excellent. Westinghouse developed a drive with numerous advanced engineering features. See if they give you an idea for your new mills and process lines.

Two things make the high speeds possible: First, Westinghouse RF *radio frequency* heating is used to "reflow" the tin (and produce the shiny surface). Second, a special control system keeps the plating current proportional to line speed and assures uniform thickness. The highly synchronized drive ties the whole complex line together.

The RF heating works so fast it produces an actual "flow line" on the moving strip. An electric eye continuously scans this flow line and uses it to maintain the precisely desired heating rate. Thus despite variations in strip speed, thickness and moisture content, there's no danger of overheating or underflow.

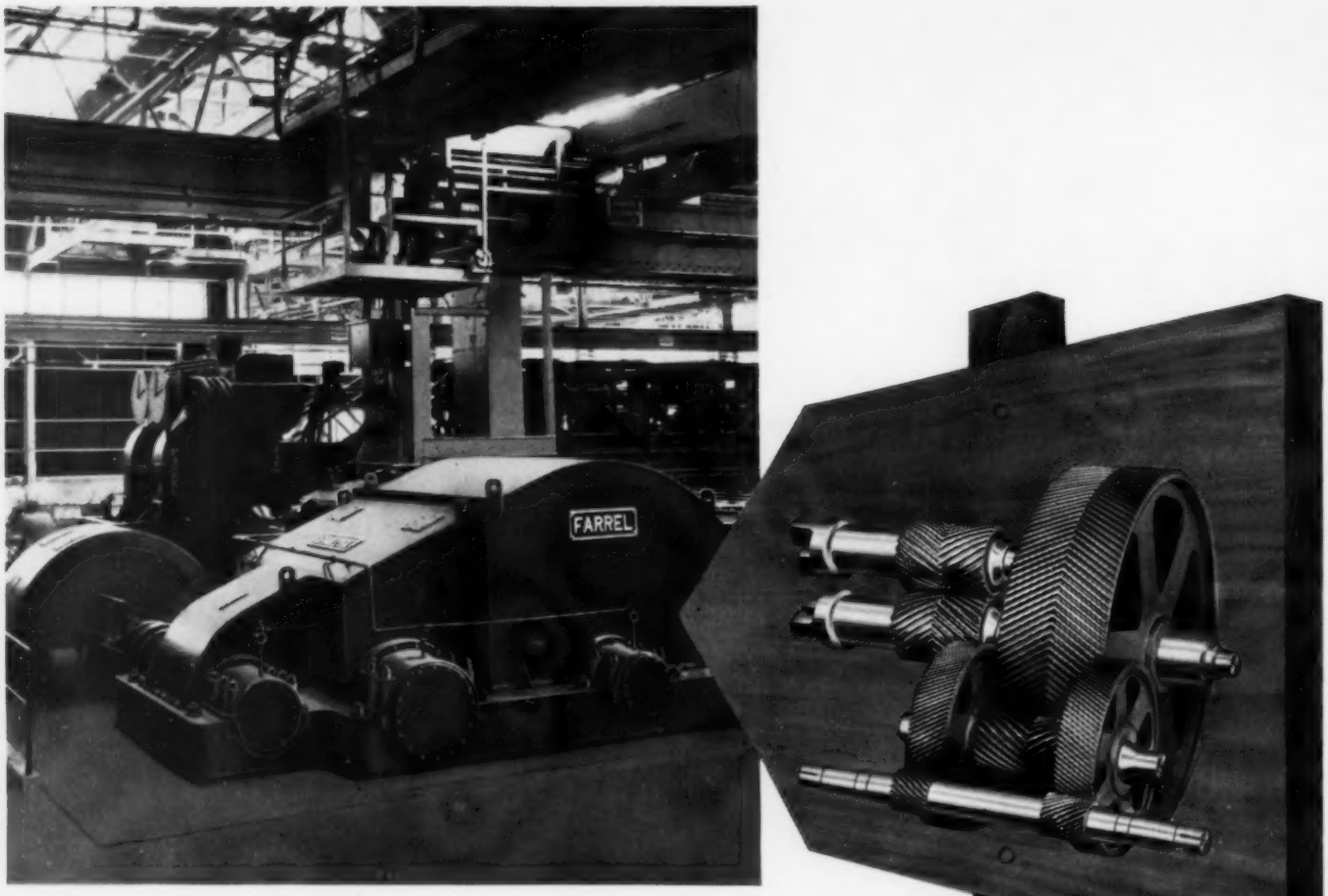
Removing finished coils and adding new ones doesn't stop the line. Extra strip in looping pits provides for slow-speed operation during changes. And the controls prevent any quality variation during the slowdown. The final quality check is a pinhole detector in the trimming line which automatically rejects any imperfect sheets.

Call Westinghouse early on your next project. Integrating these developments into a high-production, high-quality line is one of the trickiest possible drive-engineering problems. And this kind of thinking can be applied to *all* steel mill projects. Call in Westinghouse early on your next job.

J-94910

YOU CAN BE SURE... IF IT'S
Westinghouse

EQUIPMENT FOR
STEEL PRODUCTION



Guide to Better Power Transmission Efficiency

The quiet, vibration-free performance of a Farrel® combination mill drive and pinion stand is due, to a large extent, to precision generation of gears and pinions by the famous Farrel-Sykes process. This method of generation results in extreme accuracy of tooth spacing, contour and helix angle, which pays off in smooth, efficient power flow.

The mill pinions are herringbone type and the reduction gears are a combination of herringbone and split (divided) double helical gears. This makes a compact arrangement which distributes the load uniformly and requires minimum floor space.

To keep power transmission efficiency "young" through long years of service, the drive is equipped with a unit-type pressure lubricating system with separate motor-driven pump. This provides force-feed lubrication to the antifriction roller bearings and to all gears and pinions, except the second reduction gears, which are lubricated by dip and splash.

Designed to suit individual requirements, Farrel rolling mill drives and pinion stands, separate or combination units, are available in any capacity. Farrel engineers will supply full information for specific applications.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT
Plants: Ansonia and Derby, Conn., Buffalo, N. Y. FB-760
Sales Offices: Ansonia, Buffalo, New York, Akron, Pittsburgh, Chicago, Los Angeles, Houston

Farrel-Birmingham®

Another good example of Salem-Brosius leadership in diversified service to the ferrous and non-ferrous metals industries is the specially designed Brosius-Westling plate valve shown above. This ingenious mechanism is an offspring of the traditional "goggle" valve which has long been used to close massive mains containing dangerous gasses around blast furnaces and steel mills. Its major virtues are rapid shut-off and seal; easy, positive action despite long intervals of disuse; high structural strength combined with relative low weight. The development of the Brosius-Westling has so refined the principal of the sliding-plate valve that other industries currently are experimenting with its application.

If you have a problem which involves the use of heating furnaces, blast furnace equipment, or charging and manipulating machines, it will pay you to call on Salem-Brosius today.

SALEM-BROSIUS, INC.

SALES AND EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.

BROSIUS DIVISION, PITTSBURGH 15, PA. — SALEM ENGINEERING DIVISION, SALEM, OHIO

IN SALT DISPENSERS

standard models fill the bill

IN MILL ROLLS

it takes a different kind of engineering

To get volume production and high dollar returns from your rolling equipment, you know that a lot depends upon the design and engineering of your rolls. In short, it takes a different kind of roll engineering to meet your own requirements. It calls for specialized design, manufacturing control, and skilled installation of the rolls to give you the kind of results you want.

BIRDSBORO ENGINEERING SERVICE

If your rolling operations are falling short of established goals, or production costs are biting the heart out of your profits, you may find the help you're seeking with Birdsboro Engineering Service. There's no obligation to have a Birdsboro Representative give you complete information on what this service can accomplish in your plant.

BIRDSBORO

STEEL FOUNDRY & MACHINE CO.

Birdsboro, Penna.

Offering Complete Engineering and Construction Service on:

Steel Mill Machinery • Crushing Machinery • Rolls
Hydraulic Presses • Special Machinery • Steel Castings

17% fuel saving!

and a 3-month write-off!

with BLOOM Ka-Weld PRECAST REINFORCED Pipe Insulation

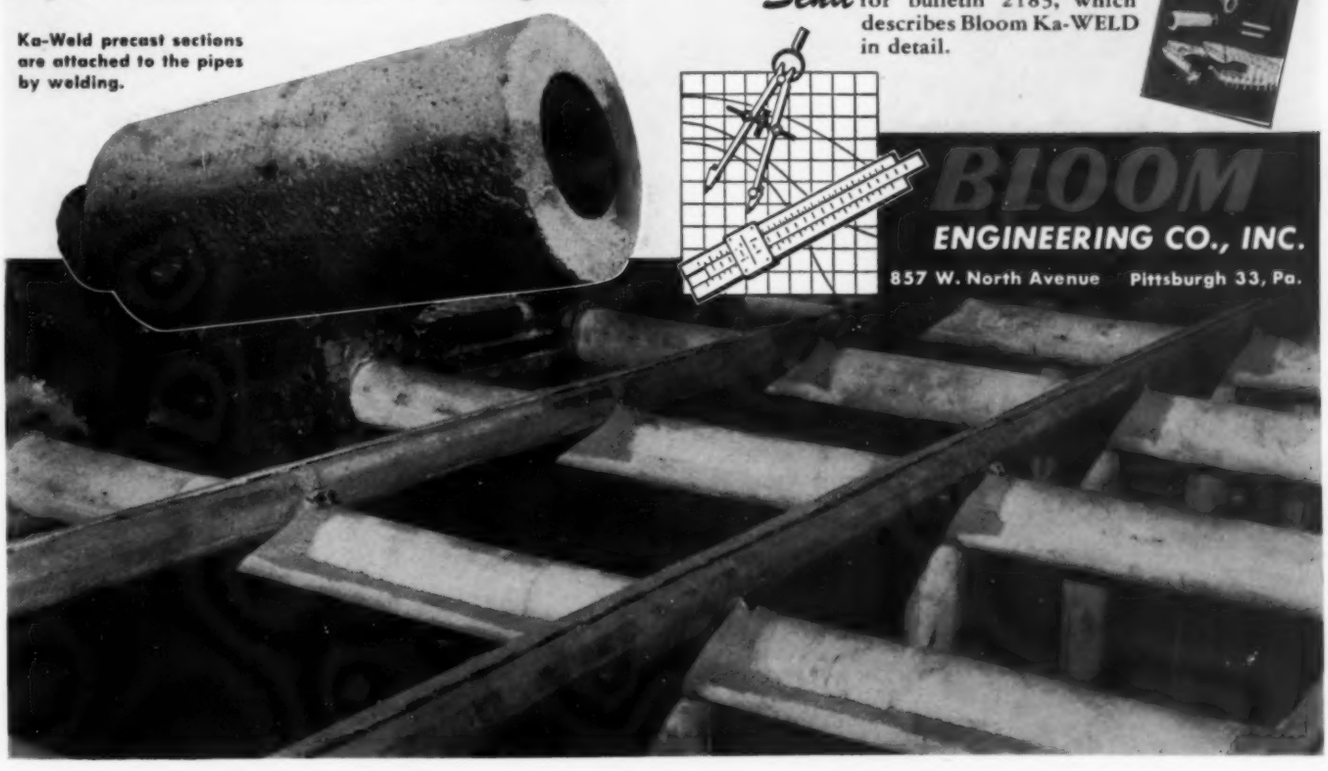
A midwestern plant reports an overall fuel savings of seventeen per cent, attributed to Bloom Ka-WELD installed on water-cooled support pipes of a strip mill furnace. As a result, complete write-off was obtained in *three months!*

Made of durable, readily-applied refractory material, Bloom Ka-WELD increases furnace output, reduces the heat-loss to cooling water, permits more uniform heating of steel due to increased bottom zone temperatures, prolongs skid life, reduces skid marks, slagging and sticking, saves water.

Such results, coupled with Bloom's one-year guarantee, make Ka-WELD an excellent investment.

Send for bulletin 2183, which describes Bloom Ka-WELD in detail.

Ka-Weld precast sections are attached to the pipes by welding.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

AMSCO MANGANESE STEEL WELDMENTS
ADD NEW LIFE TO WORN EQUIPMENT

Amsco Welding Rods and Electrodes For repair welding of manganese steel shapes to worn equipment, American Manganese Steel Electrodes retain their toughness and give real operating savings.

Amscoating with Amsco Hardfacing Rods increases service life . . . reduces shutdowns.

Contact your Amsco Distributor or write for illustrated catalog WA-77 on Amsco Manganese Steel Weldments and Hardfacing Selector Guide.

Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION
411 EAST 14th STREET • CHICAGO HEIGHTS, ILL.

Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
Amsco Welding Products distributed in Canada by Canadian Liquid Air Co., Ltd.

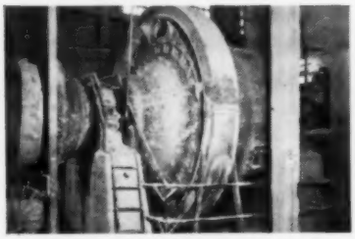
IN ALL INDUSTRIES

LUBRIPLATE LUBRICANTS

EXCEL IN REDUCING FRICTION, WEAR, UPKEEP-COSTS AND POWER-CONSUMPTION...WITH BETTER MACHINE PERFORMANCE

"LUBRIPLATE NO. 630-AA is practically a universal lubricant"

–so writes the SPOKANE PORTLAND CEMENT CO. of Irwin, Wash.



"With the introduction of LUBRIPLATE No. 630-AA, we were able to reduce our requirements so that today we are satisfying all our needs for solid type lubricants with only two LUBRIPLATE Products. LUBRIPLATE No. 630-AA might almost be considered a Universal Lubricant. Furthermore, it has effected a marked savings in lubricants and labor."

Frank D. Neill
General Superintendent

LYNCH CORPORATION of Toledo, Ohio, a leading manufacturer of packaging machinery

says:

"THIS LUBRICANT REDUCES SERVICE CALLS"

"The majority of our machines are used in places where it is necessary to wash them with steam and hot water after each day's use. This naturally would remove any ordinary lubricant and trouble would develop if the machines were not immediately relubricated. With LUBRIPLATE there is always a film left on the machine after washing. Our Service Engineers can readily spot machines that have had other than LUBRIPLATE Lubrication, as these machines do not give the service they should."

"THIS LUBRICANT SAVES 7 TIMES ITS COST IN PRODUCING SHOES" – says WOLVERINE SHOE AND TANNING CORP.

"You recommended to us LUBRIPLATE No. 100 for lubricating the chain drive on our paddle wheels which turn the hides immersed in a solution in concrete vats. The chain during use is always soaked in a solution that is sometimes acid and sometimes caustic. Up to that time we had not found any lubricant that would stay on the chains for any appreciable time. The average life of a chain was approximately one year. Since we have applied LUBRIPLATE to these chains every two weeks for two years, not one chain has required replacement, and they are still going strong.

"At this time it appears that for every dollar we have invested in LUBRIPLATE, we have saved seven dollars in chains."

REGARDLESS OF TYPE AND SIZE OF YOUR MACHINERY LUBRIPLATE LUBRICANTS IMPROVE OPERATION AND GREATLY REDUCE MAINTENANCE COSTS.

Write today for LUBRIPLATE Data Book No. 1-52

LUBRIPLATE DIVISION
Fiske Brothers Refining Co.
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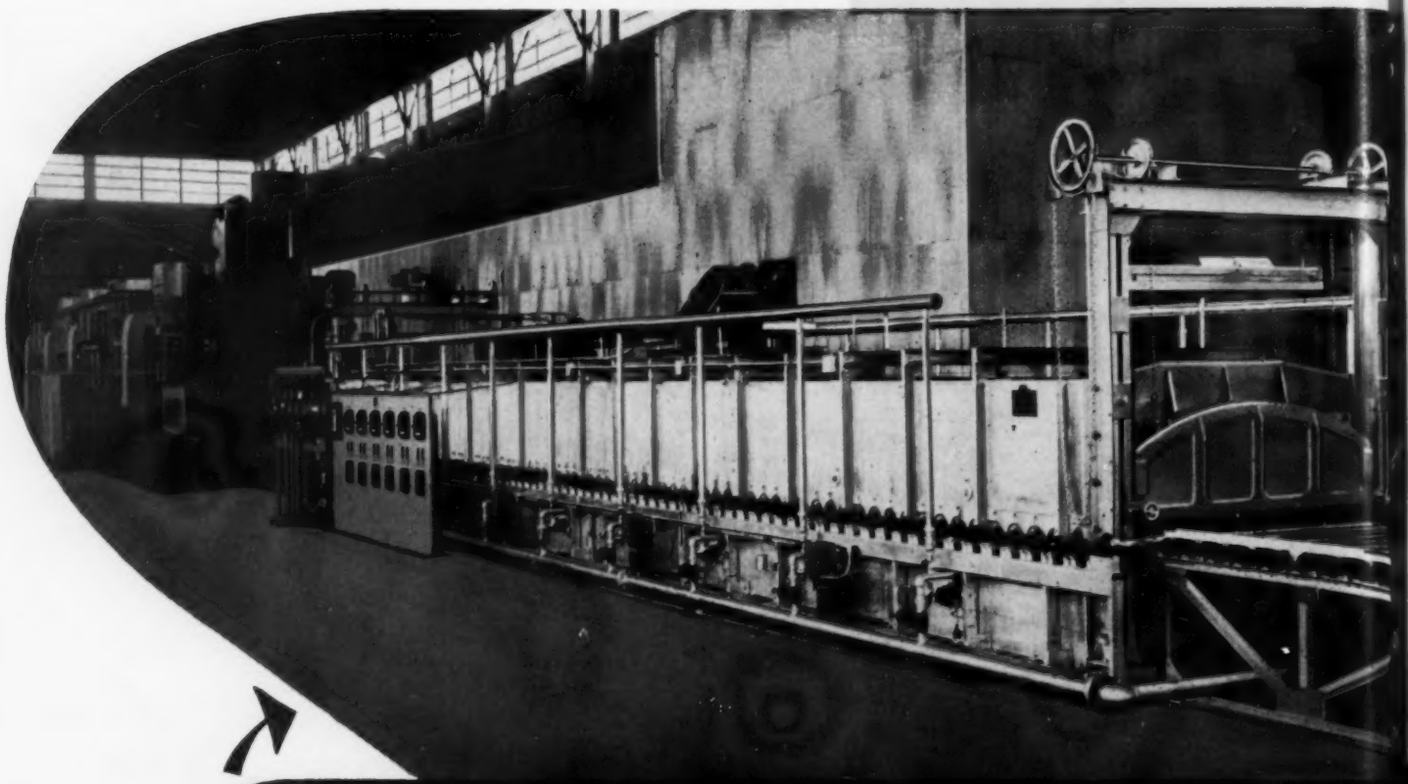
DEALERS FROM COAST TO COAST—SEE YOUR CLASSIFIED TELEPHONE BOOK

Continuous Roller-Hearth



Line approximately 260 ft. long,
12 ft. wide, 17 ft. high

for Plate

Line consists of Hardening Furnace
Tempering Furnace, Pressure Quench
and various charge and discharge tables.

Gas-Fired, Oil-Fired or Electrically Heated.

These lines are adaptable to other
products; e.g. Steel Bars.

Automatic oil quenches are available
for products requiring oil quenching.

EQUIPMENT CAN BE FURNISHED FOR ANY CAPACITY.

In addition to many lines installed during the second world war, installations in the past 18 months have been made and are in operation in the following plants:

Doehler-Jarvis Co.
Electric Autolite Co.
Florence Stove Co.
Kalamazoo Stove Co.
Metals Fabricating Co.
Rockwell Manufacturing Co.
Scaife Co.
Standard Steel Spring Co.
Newton Falls, Ohio Division
Williamson Heater Company

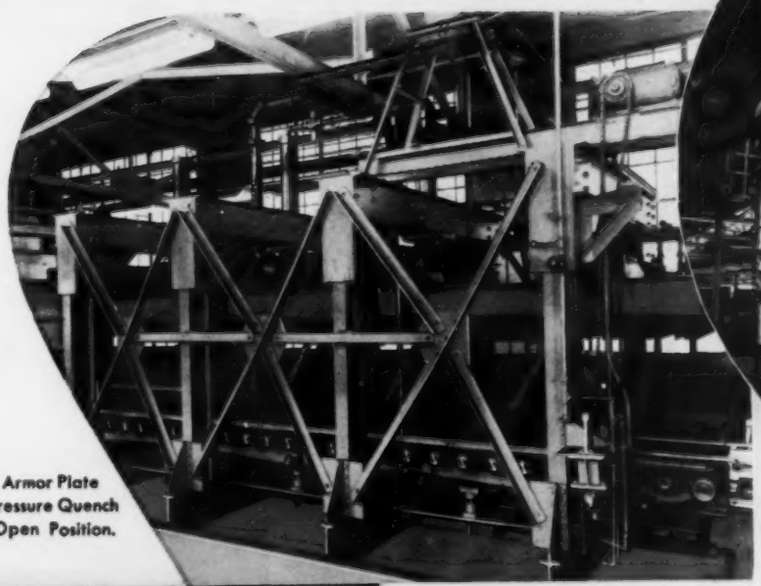
Heat Treating Lines for ARMOR PLATE

AND OTHER PRODUCTS

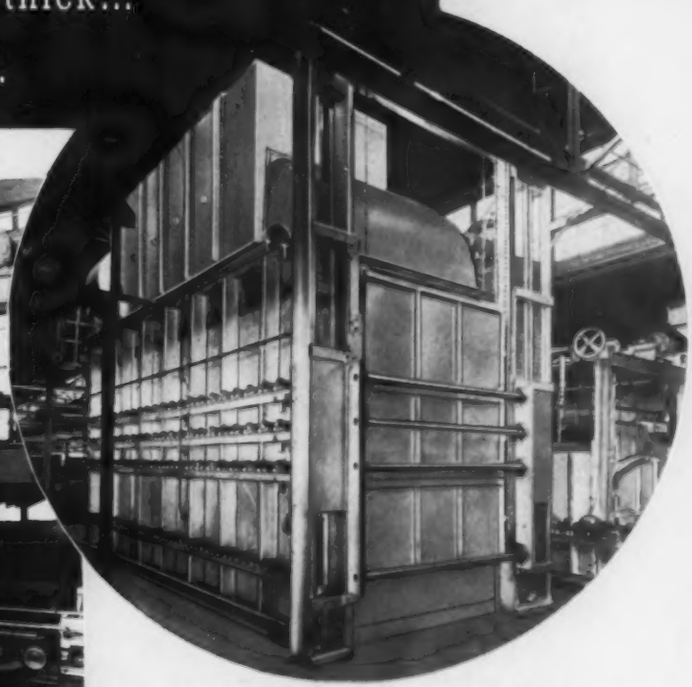
by DREVER

6' x 60' Roller-Hearth Hardening Furnace Discharge End — showing Elevating Discharge Table. Elevating Table feeds hot plate to press at variable levels.

te up to 6 ft. wide, 18 ft. long, 4" thick...
Capacity 8000 lbs./hr.



Armor Plate Pressure Quench Open Position.



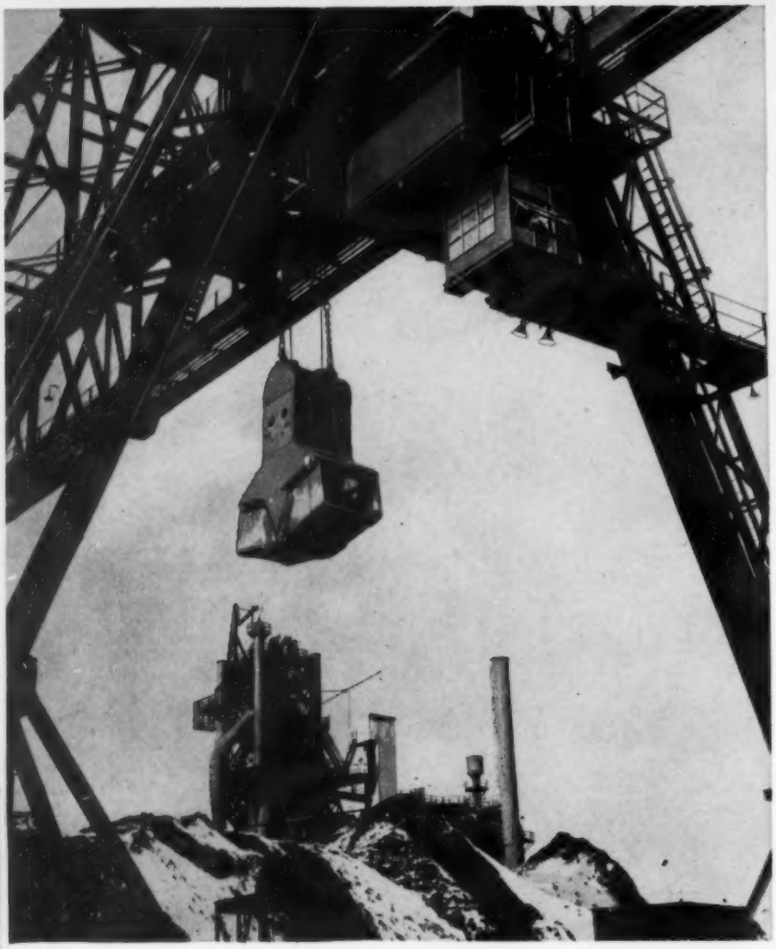
Four level Roller-Hearth Tempering Furnace.
Recirculated Air Heating.
Dimensions inside — 6' wide x 24' long x 7' high.
Capacity, 10,000 lbs/hour — temperature 1250°F.

Send your requirements to our competent and experienced staff of engineers.

DREVER CO.

730 E. VENANGO ST., PHILADELPHIA 34, PA.

THE FINEST BRIDGE



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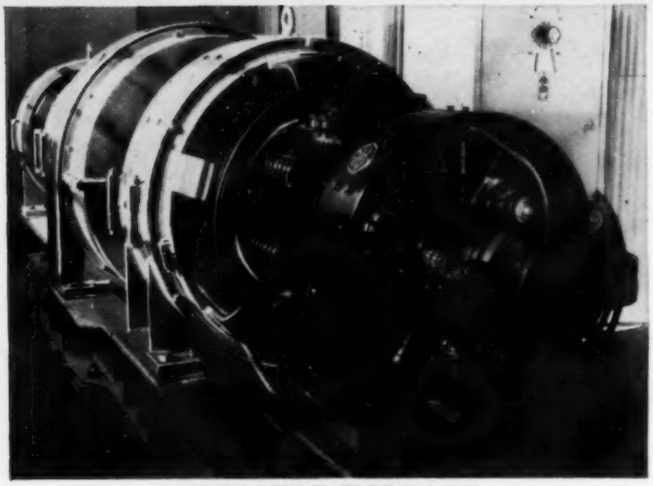


VARIABLE VOLTAGE MOTOR GENERATOR SET

The use of the multi-unit Motor Generator Set with Amplidyne Drive provides adjustable voltage direct current to the various motors producing smooth starting and stopping and the fastest possible operation. Use of this MG Set, built by General Electric Co., provides greater efficiency than the rheostatic scheme by allowing greater horsepower output from the motors. The use of this system eliminates approximately two-thirds of the control weight normally carried on the trolley. Other advantages of this variable-voltage system are: reduced space requirements; lower maintenance cost; less power loss; and elimination of heavy copper conductors.

1. An artistic view of the 12-Ton Ore and Coal Bridge, showing the Blast Furnace and Ore Pile in the background.

2. The entire Bridge showing bucket in position to unload ore from a lake vessel.

2.

This Ultra-Modern Bridge designed and erected by HEYL & PATTERSON Contains More Firsts and More "Advanced Improvements" Than Any Other Ore and Coal Bridge in Operation Today.

EVER BUILT

Designed and Erected by
Heyl & Patterson for
DOMINION FOUNDRIES and STEEL, LTD.
Hamilton, Ontario, Canada

TRUCKS

The entire bridge is mounted on fabricated steel Trucks of extra heavy sections with 24 wheels under the pier leg and 24 under the shear leg. Trucks are arranged in 3 four-wheel, two-axle units, and each unit is driven by a separate motor. The standard-gauge, wide-rail spacing permits the bridge to run on crushed slag ballast.

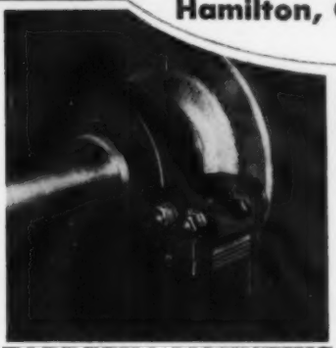
ORE BUCKET

The Heyl & Patterson 12-ton Buckets used on this bridge are built to withstand extremely rough usage. All moving parts are connected by heavy steel pins having removable bushings and the bucket spades are equipped with heavy manganese steel digging lips. The coal buckets and ore buckets are interchangeable.

This modern 12-ton ore and coal bridge is a practical example of how Heyl & Patterson constantly plans ahead to provide the utmost in new and practical features for every project . . . features that enable any H. & P. installation to operate smoothly, quickly, safely and economically.

Notice the many new and improved features of this bridge that contribute to its outstanding performance. The compact Turn-Table; the Fabreeka Mounting; the Variable-Voltage, Amplidyne Controls; the increased use of Welding . . . all designed to give this bridge better, longer performance with less maintenance cost than any other bridge.

When faced with a Heavy Bulk Materials Handling problem, think of Heyl & Patterson— the firm with experience of the past and an eye to the future.

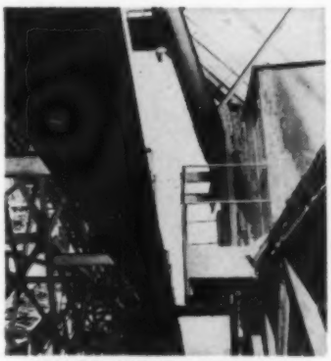


FABREEKA MOUNTING

Fabreeka Mounting is used in place of the conventional spring assembly. Fabreeka Mounting cushions and dampens the trolley; increases life of the Collector Shoes; absorbs and reduces vibration; requires no lubrication.

H&P RAIL CLAMP

The Heyl & Patterson patented Rail Clamp is a never-failing safety device. Whenever the power circuit is opened the wedge-shaped counter-weight descends and forces the hardened serrated tool steel clamping plates against the sides of the runway rails.

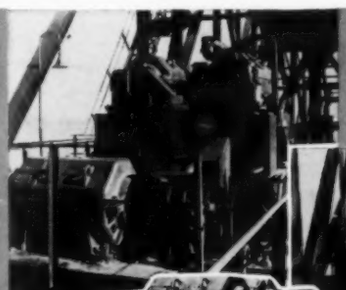


BRIDGE RUNWAY CONDUCTOR RAILS

A great saving in weight is made through the use of aluminum conductor rails. The power, 550 Volt, AC, is transmitted through the Collector Shoes.

MORE WELDING

The extensive use of welding on this bridge provides a saving of weight and added strength throughout the entire bridge. Notice the lack of rivets in the shear leg.



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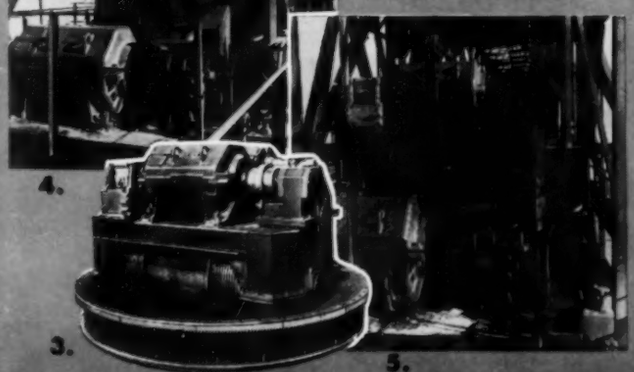


3. 5.

THE HEYL & PATTERSON TURN-TABLE

This bridge is the first installation utilizing the recently-designed Heyl & Patterson two-motor hoist mounted on a turn-table. The turn-table speeds the clean-up operation during unloading by allowing the bucket to dig from any angle in the hold of the vessel.

Because of its compact design, the trolley with the turn-table arrangement uses no more than 5% extra space between the trolley runway rails than is required for the standard trolley. This arrangement does not sacrifice accessibility of parts for inspection or repair.

The assembly is mounted on a welded lower member which is, in turn, carried on rollers supported in the trolley frame. 100° of motion can be obtained in either direction. The rotate motion is obtained by a motor driving through a reducer to a final bevel gear reduction.

3. Turn-Table. 4. The axis of the drum parallel to the trolley runway. Note wiring and gear casing. 5. The axis of the drum parallel to the bridge runway.

Heyl+Patterson, Inc.

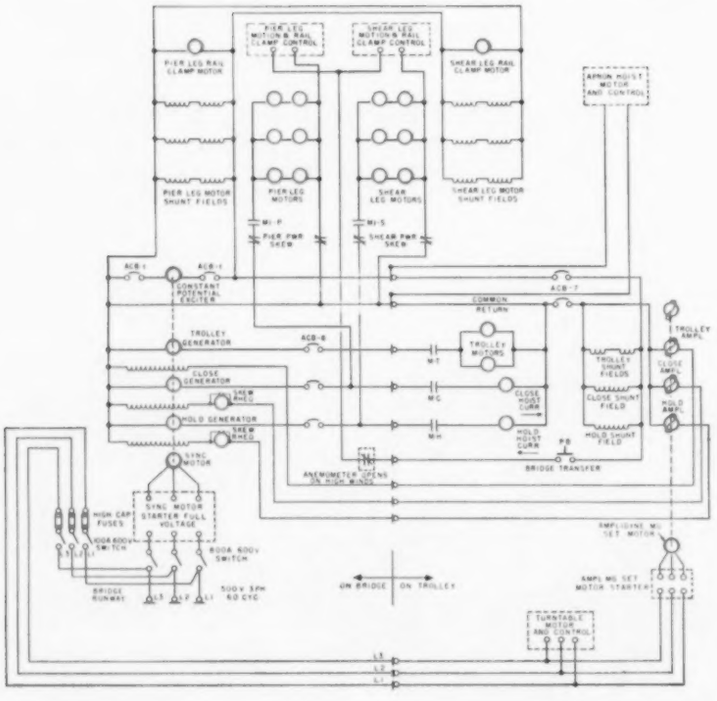
"SINCE 1887"

Heavy Bulk Materials Handling Equipment
All The Way from Design to Erection

55 WATER STREET · PITTSBURGH 22, PA.

All electric equipment for this new ore bridge was supplied by Canadian General Electric. Heyl and Patterson, Inc. of Pittsburgh designed and built the bridge for Dominion Foundries and Steel, Limited, of Hamilton, Ontario.

New ore-bridge drive gives

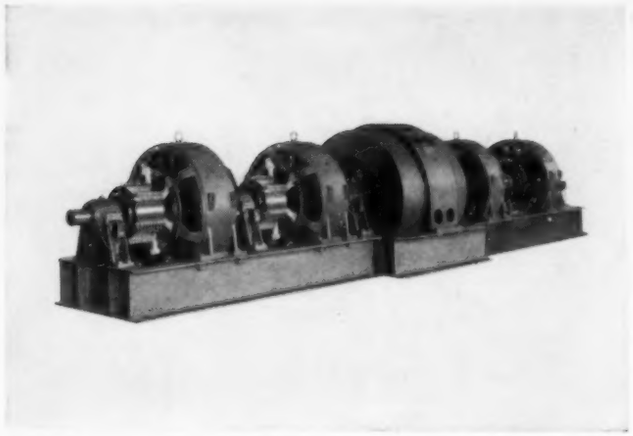


How this new drive works:

The synchronous-motor-driven generators on the bridge structure supply adjustable-voltage power to the hold, close, and trolley motors on the man-trolley; also constant-potential power for motor fields, brakes, control, and the apron hoist. Each adjustable-voltage generator is controlled by an amplidyne on the man-trolley. In addition to voltage- and current-limit control, the hold and close line amplidyne circuits include provision for automatically matching motor loads when hoisting or lowering a closed bucket or matching motor speeds when lowering an open bucket.

By means of a foot switch, the operator transfers the hold and close generators and control to the pier and shear leg drives; thereby obtaining smooth acceleration and deceleration of the bridge structure. Each leg may be controlled independently, but when operated simultaneously, automatic alignment is provided by means of skew rheostats.

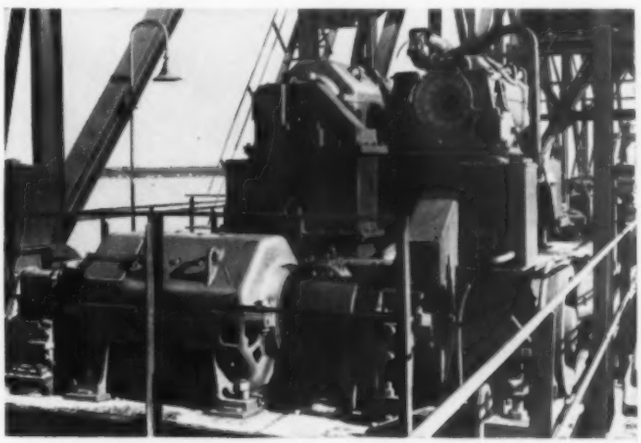
Another Example of G-E drive engineering at work!



Amplidyne-excited generators in the main 5-unit m-g set (similar to one above) power trolley, hold, close, and bridge travel motors.

Apron hoist that permits raising apron for ore boat's entry is driven by a sturdy G-E 45-hp mill-type d-c motor.

Three of 12 G-E mill-type d-c motors and brakes that drive the shear and pier legs. Automatic skew control maintains alignment between legs.



Top deck of trolley contains four 150-hp continuous rated G-E mill motors for hold, close (on turntable) and trolley drives, each equipped with a G-E mill-type brake.

more precise bucket control

Amplidyne adjustable-voltage system also speeds trolley travel, cuts power losses and maintenance costs

Here is the first application of an amplidyne-controlled adjustable-voltage drive system to an ore bridge—engineered jointly by Canadian General Electric and Heyl and Patterson, Inc. of Pittsburgh. This drive system, already proved in other industries, now brings to ore bridge operation these major advantages:

More accurate bucket control, with less master switch handling and less operator fatigue, because load is divided and speed matched *automatically* between hold and close motors.

Faster trolley travel, with less shock to gears, because constant rate of acceleration and deceleration brings trolley up to full rated speed faster, stops it in less time.

Less power consumption because there are no banks of power resistors to cause power losses.

Smaller, lighter trolley design, because large banks of power resistors and heavy power contactors are eliminated, smaller frame motors and brakes are used.

Less maintenance, because resistors and power-interrupting contactors are done away with, smooth acceleration and deceleration minimizes stress on structural members.

What does this example mean to you? Simply this: G-E engineering successfully uses the *system* approach to solve any drive problem—including *yours.* For more information, contact your G-E steel-mill specialist or write for Bulletin GET-1789A. *General Electric Company, Section 659-89, Schenectady 5, N. Y.*

GENERAL ELECTRIC

Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND CRANE
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

LAST January this page, in discussing negotiations between the steel producers and the United Steel Workers, stated that, "The government agencies will probably find a way to bend wage and price ceilings, the union will accept a reduction in its demands, and the companies will grant the reduced demands in return for a price increase." This has at long last come to pass. But the intervening seven months witnessed a tragic spectacle of government bungling and political partisanship that resulted in the longest steel strike in our history, with a loss of some 20,000,000 tons of steel production and a loss of about $600 per man by the steel workers, plus all the attendant repercussions.

Final settlement, which could have been reached at almost any time since last March, consists of a 22-cent hourly package of wage increases and fringe benefits (which had been offered some weeks prior), and a grudgingly granted steel price increase averaging about $5.65 per ton (which is the figure that defense mobilizer Charles E. Wilson wanted to settle for before his resignation on April 1st).

It will take the steel workers 18 months or more to make up their lost wages; the increases in wages and prices will no doubt set off further inflation; and our defense preparations have suffered some delays of indeterminate importance. If any good can be said to come of the strike, it might be the reminder to the union that the industry will steadfastly resist the union shop, the discovery by government that it cannot casually seize private property and cannot freeze prices without also freezing wages, and the realization by both union and industry that settlement between themselves, without governmental meddling, is advantageous to both.

▲

DURING the steel strike a woman member of the United Steel Workers wrote a letter to the Pittsburgh newspapers urging that union members be allowed to vote on the union shop question and whether they wanted to go back to work. She was called before a special meeting of her local, where the local's officers read a statement to her which said they recognized her right of free speech, but "if you hastily publicize your feelings in an emotional crisis where you cannot fully appreciate the reason for the strike, you will be destroying your only hope for a better America, for we are the only ones who can help you." They also told her that in Russia her statement never would have got into the newspapers.

As far as we know, they didn't tell her what happens to strikers in Russia.

PERHAPS it was the recent heat wave that prompted a correspondent to send in the following:

I'm glad the sky is painted blue,
And the earth is painted green,
But what became of the cool fresh air
That was sandwiched in between?

▲

AS convention orators finished pointing with pride and viewing with alarm and the last "a-man-who" echoed from the lofty ceiling of Chicago's International Amphitheater, the two major political parties ended up with good candidates for the offices of president and vice-president of the United States, a result seemingly miraculous to a neophyte following on television the antics and machinations of the conventions. In general, it might be said that the Republican convention followed the popular vote of its primary elections, while the Democratic convention by-passed its "peoples' choice" in favor of the professional politician's selection.

And next comes the campaign and the election — and here we should consider some statistics. Prior to 1920 (and incidentally, prior to woman's voting), between 70 and 80 per cent of the eligible voters in the United States voted in national elections. Beginning in 1920, this percentage has hovered between 49 and 55. There are more than 95,000,000 eligibles in the United States yet the 1948 vote was only 48,680,416. There are at present more than 29,000,000 eligibles not even registered to vote.

This is a shocking disregard of the principles of democracy and the privileges of freedom. Everyone who believes in these principles should act as a committee of one to do what is possible to get out the vote — and to put in a plug for his favorite candidate.

▲

AFTER the foregoing patriotic (and neutral) remarks, perhaps we will be permitted the personal opinion that, since all houses need a thorough cleaning once in a while, we think it's time for a change.

▲

REPUBLICANS should remember Al Smith's classic remark: "Nobody shoots at Santa Claus" — and then ponder the fact that some 25,000,000 individuals receive checks from the federal government.

▲

IF all of the automobiles in the United States were placed end to end, half of the drivers would immediately pull out to pass the car ahead.

▲

TO counteract the effect of the steel strike on iron ore shipments and to avoid curtailed operations next winter, United States Steel Co. is starting some all-rail ore shipments direct from mine to plant before freezing weather sets in.

▲

CIVILIZATION! It's wonderful! It brought us from shoeless toes to toeless shoes.

These two Elliott blast furnace blowers will soon be supplemented by a third identical unit. Each blower is rated at 100,000 inlet cfm of air at a discharge pressure of 30 psig. Blowers driven by Elliott 11,500-hp condensing turbines.

. . . are a major factor in the expansion program of United States Steel's Ohio Works, Youngstown, Ohio. The two big turbine-driven blast furnace blower units, illustrated, went into service last summer. Incidentally, Elliott helped speed up the modernizing and expansion program—the first blower was installed and operating ten months after the order was placed; the second unit a month later. After six months of smooth operation a third Elliott unit was ordered to continue the program for the new blower house, replacing old blowing engines.

These Elliott blowers, operating at pressures up to 30 psig, give the desired higher pressures which give smoother furnace operation. They provide even, continuous flow of air, adaptable to close control and insuring best furnace performance. The blower design features all-welded impellers with smooth fillets at all joints to minimize wear. Based upon years of service handling dirty air or gas, these welded impellers are expected to greatly outperform old-style riveted designs.

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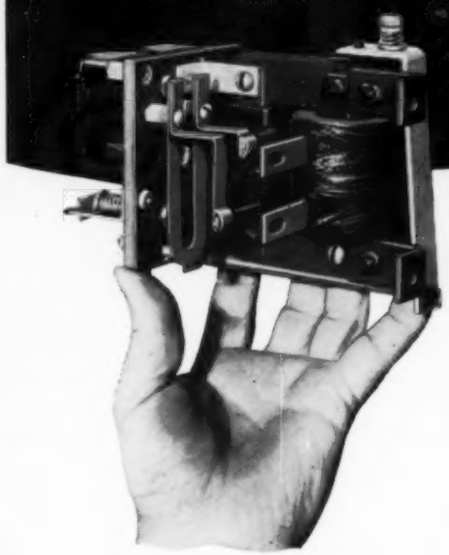
P2-1

Independent *trips* save electrician's time in locating trouble



¾ rear view shows independent thermal and magnetic tripping elements—both are adjustable. Relay is front-connected, removable as a unit from the mounting-base.

When a motor stops, the electrician soon finds whether an *over-current* or a *fault* has caused the shutdown. EC&M THERMAL-MAGNETIC Overload Relays have independent thermal and instantaneous tripping elements operated from *one magnetic source*. Contacts are also independent with the instantaneous-element regularly furnished with hand-reset contacts. A quick look distinguishes between wiring trouble and motor overloading—*cuts downtime up to half*.

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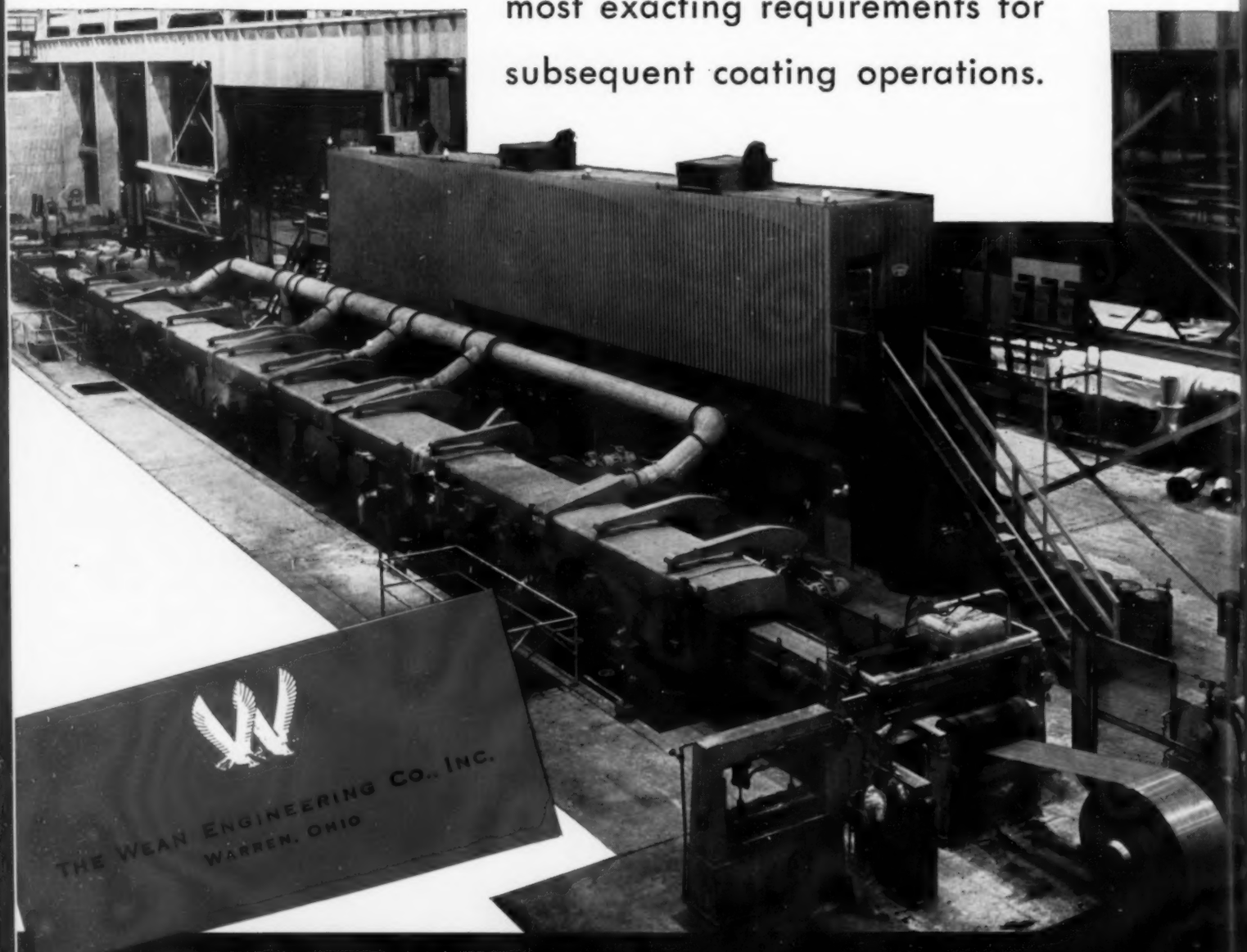

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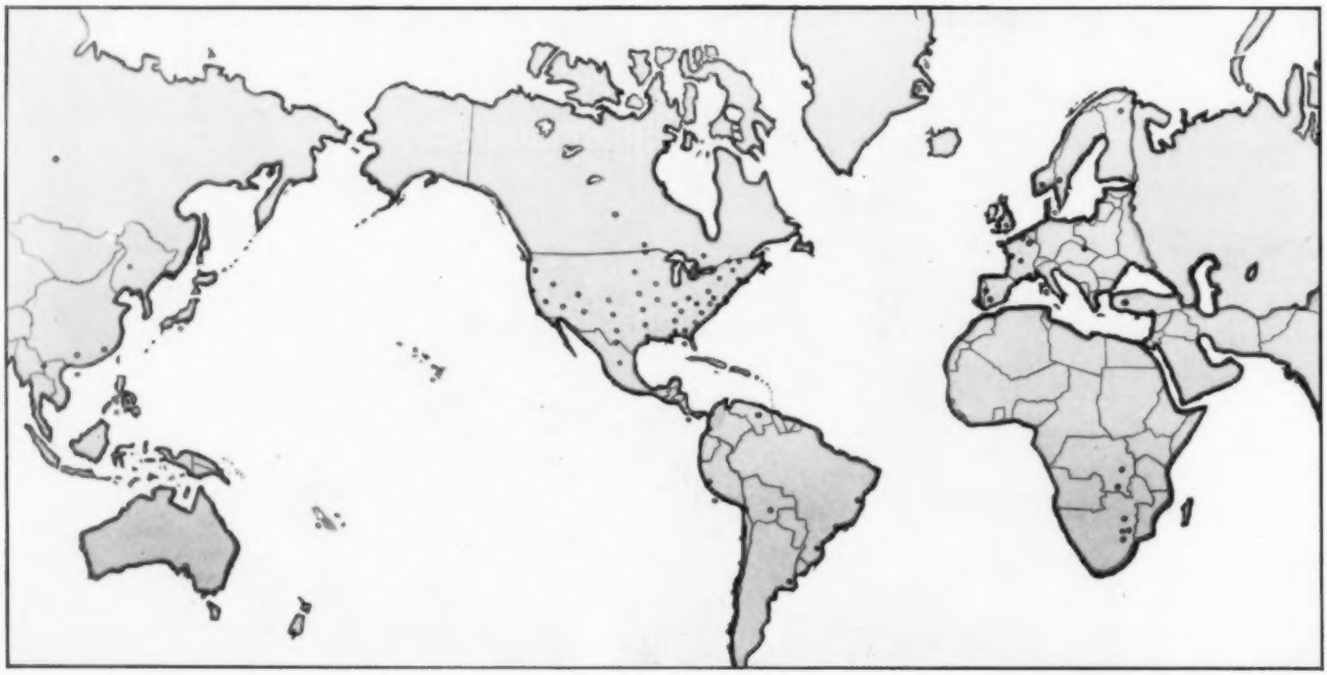

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WHEN YOU MELT... MOORE RAPID *Lectromelt*

SYMPOSIUM ON FIRING AND CONTROLLING

Open Hearth Furnaces

. . . . much of the increase in steel production can be attributed to the development of modern burners and to controls which aid in operating the furnace . . . .

"MULTIPLE BURNERS FOR FIRING THE OPEN HEARTH FURNACE"

By W. H. KAHL, Combustion Engineer
No. 2 Open Hearth
Inland Steel Co.
East Chicago, Ind.

▲ THE use of multiple burners for firing open hearth furnaces at the Inland Steel Co., Indiana Harbor Works, should appropriately be represented as one phase of a program designed for increasing tons per hour of steel produced, while maintaining furnace availability.

For the purpose of this discussion, only one size furnace will be considered, one designed for 168 net tons, now rated at 200 net tons, tapping an average of 205 net tons for the year of 1951. The increase in heat size of 37 tons or 22 per cent involves many complex problems for the open hearth operator as well as the fuel engineer.

Some of the major problems arising as a result of the increased tonnage are:

1. Bath depth increases approximately 18 per cent.
2. Cold metallics weight and charging time is increased.
3. Non-metallics weight and charging time is increased.
4. Hot metal delivery and addition time is increased.
5. Higher slag volumes must be handled.
6. Fuel rates must be adjusted to compensate for the increased total charge.

To the above major considerations, many other conditions develop and must be recognized and compensated for throughout the process. Faced with fixed external furnace dimensions, increased bath depth, deteriorating scrap quality and increased limestone burden due to sulphur content of scrap and fuel oil a program was initiated to alleviate where possible, some or all of these problems.

Bath depth, of critical importance to the operation, could be attacked only by internal lengthening of the hearth through movement of the chill box areas outward. This immediately posed a fresh problem on incoming air for combustion as well as exit waste gas flow from the hearth. With the furnace of front and rear uptake design, elimination of the dividing arch would compensate for the outward movement of the chill boxes.

With the installation of our first basic end, it was decided to omit the dividing arch, without moving the chill boxes, to investigate the operating possibilities involved.

Two campaigns on this furnace with a single uptake area of 113.88 sq ft as compared to the normal 86.5 sq ft combined front and rear uptake area were disappointing with respect to production and fuel consumption. The furnace required hard driving throughout both campaigns, and tests conducted during operations proved incoming air for combustion was concentrated along the pit wall of the uptake and through the rear section of the hearth area in its travel to the downtake.

The dividing arch was installed at the start of the third campaign and the furnace immediately improved. Production for two campaigns of single uptake operation averaged 12.88 tons per operating hour at 25.1 gal oil per ton as compared to 14.5 tons per operating hour at 22.4 gal oil per ton for the third campaign with the dividing arch again installed.

Light, bulky scrap charges necessitating occasional slow oil for melting through, plus a desire to efficiently introduce a higher hourly Btu input to the cold charge through better utilization of incoming air, led to the installation of auxiliary fuel burners on a conventional double uptake furnace. The regular 6-in. artillery type burner handling atomized fuel oil coke oven gas, plus oxygen for flame enrichment was retained in its original setting.

A 5-in. artillery type burner was installed over each uptake, making a total of three burners on each end of the furnace. The auxiliary burners were set at slightly higher elevation for the purpose of slope and knuckle clearance while in operation.

Separate oil and steam manifolds were provided for the front and rear burners along with necessary gauges, oil meters, recorders and flow control valves. On-off control was obtained through diaphragm operated

valves installed at the furnace ends, actuated by manual selector valves on the furnace panel board.

Experiments with this installation involving various burner combinations and fuel rates led us to a meltdown practice involving only the front and rear burner in operation on atomized fuel oil with the center burner feeding oxygen for combustion support. Hourly Btu input was increased from approximately 72,500,000 on single burner operation to approximately 90,000,000 on the multiple burner installation. This was, and is, the maximum rate we could introduce, and still maintain waste gas analysis in operating limits due to present forced and induced draft fans, plus the ability of the furnace to stand up to these rates.

Extremely gratifying production and fuel consumption was obtained during the testing period. Standard practice was to fire the front and rear burners through the entire meltdown period and then switch to the regular or middle burner after hot metal addition.

Among the advantages noted were:

1. Ability to efficiently increase hourly Btu input.
2. Better coverage of hearth area.
3. Greater utilization of incoming air.
4. Elimination of slow oil periods due to bulky scrap.
5. Accelerated meltdown.
6. Increase in tons per hour, charge-to-tap and tap-to-tap.
7. Reduction in Btu consumption per ton steel produced.
8. Rapid attainment of regenerators to working temperatures.

Among the disadvantages noted were:

1. Fast charging is a necessity if full benefit is to be gained.
2. Metal deliveries must be accurately timed and added to realize the benefit of the accelerated meltdown.
3. Critical roof temperatures over firing position can lead to serious refractory abuse if not closely watched.
4. Serious interference with pan stand provisions at the ends of the furnace.

The overall evaluation of performance justified a variation in uptake construction utilizing multiple burners for firing the redesigned furnace. Chill boxes were retained in their original position and by means of suspended basic construction, a semi-venturi type uptake was installed with a total area of 60 sq ft at the throat.

Two 5-in. artillery burners were installed on each end of the furnace with discharge tips roughly trisecting the uptake. These burners handled atomized fuel oil, coke oven gas, and oxygen for flame enrichment. Two campaigns on this furnace resulted in an overall gain of slightly better than one ton per hour tap-to-tap over the remaining furnaces of the same size. This gratifying production increase was obtained at a cost of approximately 2.5 gal per ton oil above normal consumption. This undesirable development was attributed to improper turndown ratios in the burner installation, making it necessary to introduce a higher volume of fuel during the lime pulling and refining periods than is necessary on single burner operation. A variable orifice at the discharge end of each burner would be one solution to the problem, since the comparatively small volumes fed through each burner during critical stages of the heat could be accelerated and flame length subsequently increased. Without any means of compensating for the burner tip discharge area, it was necessary to increase the total fuel input through the two burners in order to accomplish the same work normally carried on through a single burner at a lower fuel input, but with a longer flame over the hearth area. Due to air distribution and the angles of fire on the dual burners, operation on only one of the dual burners was proved unsatisfactory.

A further change was made in this furnace at the next rebuild by introducing the third burner in each end of the furnace. Again the purpose of the middle burner was for operation after hot metal addition on through to tap. A time automatic reversal unit was also installed and placed in service after this rebuild. The productivity of this unit was retained and fuel consumption once more fell into line employing the burners as outlined above. No factual data can be offered at this time with respect to the automatic reversal effect on the furnace. Operating personnel indicate great satisfaction with the reversal operation, and feel it is of benefit to performance. Justification for this will be extremely difficult to evaluate due to the tremendous number of variables that merit consideration.

A second three burner installation was made over an identical single uptake. Chill boxes were moved outward 12 in. each, and new ends rammed in. The slight additional gain in hearth area on this furnace was more than offset by its location at a main pan car crossover switch. Production varied from slightly above to slightly below average and at the end of the first campaign was slightly below average over the 500 plus heats involved.

The third multiple burner installation has been completed with further change in basic end construction. Uptake area has been reduced to approximately 47 sq ft with the chill boxes moved outward 25⅞ in. each. A completely new rammed bottom was installed with a hearth area of 868.5 sq ft as compared to 757 sq ft on the remaining 200-ton furnaces. Bath depth is again at 36 in. at the taphole from sill plate elevation or 41 in. from foreplate elevation. Production and fuel performance during the early stages of this campaign are exceptionally encouraging.

The same basic pattern outlined in the first installation of multiple burners has been followed throughout on other furnaces. Other auxiliary equipment employed on each furnace includes automatic furnace pressure control, draft differential recorders, checker temperature recorders, and individual oxygen, air, and coke oven gas flow meters.

It is apparent that firing with multiple burners represents the outgrowth of a series of experimental programs conducted to solve some of the prevailing conditions within a specific installation. Generally speaking, the open hearth furnace and its successful operation must be considered as a compromise, wherein good features and practices are balanced against bad so that the net result is maximum production with maximum furnace availability at minimum costs.

Multiple burner installations to date have shown us

one method of accomplishing the easing of some of our problems. Current and future investigations may reveal other methods even more desirable in the overall picture.

"OPEN HEARTH FURNACE CONTROLS"

By GEORGE J. GOCKSTETTER, District Combustion Engineer
Republic Steel Corp.
Chicago, Ill.

THE use of automatic controls on the open hearth shops is not new, but it has only been in the past few years that we have learned to obtain the most from these controls through increased production, lower fuel cost and improved and more consistent metallurgical quality. Not too long ago, the only tools a first helper had with which to fire his furnace were a pocket watch used to time the reversals and a steam and oil pressure gauge. Meters were installed solely for the purpose of fuel accounting and were not intended for use of the furnace operators.

Even at this time it was common knowledge that the open hearth furnace was the industry's largest consumer of fuel, and even with the most advantageous fuel prices, the annual consumption of fuel on one furnace would run into thousands of dollars. Faced with these figures, it was apparent that any means of effecting even a small percentage of economy would be justified many fold.

Since most of the heat on an open hearth furnace is transmitted to the bath by radiation, which is subject to change with the fourth power of the absolute temperature, the earliest attempts to effect economy centered upon methods of increasing and controlling furnace temperatures. The resultant higher furnace temperatures produced considerable improvement in the rate of heat transfer to the bath, but this was limited by the refractories available at this time. It was found that the refractory life could be improved utilizing improved methods, and by furnace design, to prevent direct flame impingement upon the refractories, before the flame temperature had been reduced by radiation. As the furnace design progressed, it became very desirable to control the many variables which affect flame temperature and to attempt to hold them to a close tolerance.

The first step toward control of these variables was made when the indicating as well as recording flow meters were installed for the benefit of the first helpers to aid in properly fueling his furnace. Unfortunately many of these soon fell into ill repute due to poor installation and lack of proper maintenance. It was not too long before the men lost confidence in the meters and disregarded them.

FURNACE PRESSURE

In spite of all the difficulties encountered, it was recognized quite early in the development of the open hearth furnace, that furnace pressure was very important in holding the flame temperatures and patterns to the close tolerances required. Early tests indicated that as much as 40 per cent of the combustion air did not enter through the checker chambers, but by infiltration through brick work, charging doors and wicket holes. This high percentage of cold air infiltration was partly due to the fact that it was impossible to maintain stable positive pressure within the furnace.

It had been shown that the stack effect in an open hearth furnace resulted in a pressure rise of 0.013 in. of water column for every ft of furnace height. For example, in a furnace with a height of 25 ft and a zero pressure at the base of the checkers, a pressure of 0.325 in. of water column could be expected at the roof. Other investigations indicated that the practical limit of pressure on the furnace roof was about 0.09 in. of water column. If this value was exceeded, excessive roof deterioration could be expected. This meant that a reasonable compromise had to be obtained in order to limit infiltration to the furnace and yet avoid excessive roof replacement; therefore the zero pressure point in the furnace was carried at a point even with the wicket holes on the furnace doors. This of course would vary from plant to plant and with the different designs of open hearth furnaces.

In order to properly appreciate the importance of the location of the zero pressure point in an open hearth furnace, one must realize that an opening of one square foot with a differential pressure of 0.01 in. of water column will pass approximately 13,700 cu ft of atmosphere air per hr. When this relationship is applied to the charging doors of the open hearth, it becomes apparent that tremendous infiltration could occur when a furnace pressure is not maintained at the optimum. For example, assuming a 50 per cent factor of infiltration, with an ambient air temperature of 60 F, and a preheated air temperature of 2400 F, the total air temperature would be dropped to 1045 F and the flame temperature would show a decrease from 4400 F to 4100 F. It is a well known fact that regeneration is necessary in the operation of a steel melting furnace, and that anything we can do to raise the air preheat temperatures will reflect itself in increased tonnage and improved fuel economy. Illustrating in another way the value of higher air pre-heat temperatures, let us assume an air temperature of 2000 F and a fuel input of 90,000,000 Btu per hour, the total heat input would be 90,000,000 plus 31,000,000 or a total of 121,000,000 Btu per hour. Through increasing the air preheat temperature alone to 2500 F and with the same fuel input of 90,000,000 Btu, the total heat to the furnace would be 142,000,000 Btu, an increase of 21,000,000 Btu per hour by raising the air temperatures only. These figures were based on Bunker C oil with steam atomization and with 10 gr of moisture per cu ft of air.

Thus, an open hearth furnace pressure control demanded far greater accuracy than would be necessary for most other applications. It was shown that under normal conditions an operator was able to maintain furnace pressure manually with accuracies approaching plus or minus 0.05 in. of water column. This resulted in a change in the zero pressure point of about plus or minus 4 ft. With automatic control it was possible to control this pressure with accuracies of plus or

minus 0.0025 in. of water or in other words, maintain a zero zone at the wicket hole to plus or minus approximately 6 in. Most of the early furnace pressure control systems operated the main stack damper. Some installations were made in which the stack draft was killed by introducing cold air at the base of the stack, others by controlling the louvers at the inlet to the induced draft fan or after waste heat boilers, or using Isley, or the Venturi type stacks. With accuracies of plus or minus 0.0025 in. of water, it was found highly desirable to actually measure the differential pressure across the furnace roof rather than control the relative value. This eliminated the possibilities of gusts of wind changing the reference points, thermal heads and other little problems incidental to the holding of such high accuracy.

FUEL AND AIR CONTROL

Fuel and air input rank after the furnace pressure regulation in importance of the control of the open hearth furnace to maintain the maximum desirable temperature without exceeding the high limit. Early installations usually provided a fuel input control which would hold the fuel input to a desired value with a high degree of accuracy, in conjunction with which an air flow control was provided to enable the first helper to hold this variable to a constant value. This was not practical on furnaces in which natural draft was used to provide the air for combustion, because it was practically impossible to use the saucer type valve as an automatic control valve. It was only after the advent of the forced draft fan in which the air could actually be measured and controlled by means of louvers or butterfly valves that it was possible to properly control and maintain the desired amount of air input to a furnace.

Later developments have shown the desirability of fuel-air ratio control. This type of equipment would consist of a regulator capable of measuring the fuel input and controlling the air as required for the combustion. Generally the fuel air ratio regulator would have to be adjusted to compensate for the infiltration resulting from the compromise of the zero point in the furnace. Obviously the air infiltration would vary with the degree of looseness of the furnace below the floor, and it is for this reason many people have not completely accepted fuel-air ratio control on open hearth furnaces.

FURNACE REVERSAL

Automatic furnace reversal properly ranks after fuel and air control in importance to the open hearth furnace; however, quite often it is an easier problem to demonstrate its value than in the case of the fuel and air control. With automatic reversal it is possible to greatly speed up reversal time to avoid over-heating the checker chambers and maintain a better balanced furnace. It relieves the first helper, to a large extent, of the work and responsibility of reversing a furnace exactly on schedule. This usually results in material benefits through increased production and improved refractory life. It has been demonstrated also that it is possible to reverse a furnace faster, that is, with less fuel off time.

Most of the early reversal systems were operated on a time basis, and there are still many plants which prefer this method of reversal. The prime purpose of a regenerative furnace is to conserve heat and to obtain high flame temperatures. It is logical that with any system of regeneration, a reversal system using any type control should be based on the fact that it is closely related to the temperature conditions within the regenerators. Thermocouples or radiation pyrometers may be used for measuring the checker temperatures, the former where temperature conditions are favorable to thermocouple life at or near the outlet flues; the latter where high temperatures exist, such as, above the checker work. When interest was first aroused, checker temperature measurements were made with high temperature thermocouples such as platinum. The severe conditions of a melting furnace resulted in such high maintenance costs that the point of temperature measurement was progressively moved towards the outlet flue where conditions were more favorable to thermocouple life. Such a measurement does not provide the desirable information for reversing some types of furnaces, since it is only a measurement of exhaust and inlet gases. Ideally a measurement of true air or gas temperature entering the furnace proper would be of the greatest operating value. Unfortunately the inherent operating difficulty attending the aspirating thermocouples used to take measurements in the uptakes has shown to date, that no practical method exists for continuous measurement of gas temperatures. However, a practical approach would be to measure the surface temperature of a relatively large area such as the top courses of the checker brick or the roof of the checker chamber itself using radiation pyrometers. With this method of measurement the disadvantages of high maintenance and single point thermocouples are eliminated. The surface conditions of the refractory sighted upon have practically no effect on the measurement, since the condition of the checker chamber closely approaches that of a true black body condition. Any variation in temperature between the different top course areas, due to poor distribution through the system, will produce radiation readings which are nearer the hottest temperatures and not the mean, due to the inherent fourth power characteristic of radiation measurements.

Comparison between thermocouple and radiation measurements have been made, showing that the respective cooling and heating rates have indicated a much closer relation between radiation measurements and actual air and gas temperatures. With thermocouples installed in the flues, the cooling curve would drop off rapidly due to the atmospheric temperature if it were not for the thermal lag presented by the protection tube, and its response to the radiant heat of the flue walls. The cooling curve is also dependent, to a certain extent, upon the rate of air flow past the thermocouple. It is obvious that such measurement would definitely bear no relationship to the temperature of the preheated air.

Although the "Fuel Off Time" during an automatic

furnace reversal may be 20-30 sec, an additional 30 sec may be required with full fuel rates before good combustion conditions can be re-established. Operating practice definitely indicates that a considerably longer period exists following each reversal before the heat losses from the furnace and the bath have been regained, and an effective working heat head has been established. This emphasizes the importance of doing everything possible during the reversing cycle to purge the outgoing checkers and readmit the combustion air to the incoming burner point and readmit fuel under good combustion conditions in the shortest possible time. Some plants are reversing open hearth furnaces with a fuel off time of 8 sec, with 4 sec of this time being consumed in the reversal of the dampers in the waste gas flues. Any attempts to bring the fuel back into the furnace in less than 8 sec has resulted in excessive smoking due to incomplete combustion. During the reversal cycle the stack damper, and louvers on the forced draft fan are opened, and full head of steam at 300 psi is put through the burner on the end to be fired. These changes have made it possible to reverse the furnace without smoking and reducing the fuel off time from 18 to 8 sec. The limitations are the capacity of the induced and forced draft fans. Attempts have been made to analyze the waste gases during the reversal cycle, only to find that the sampling and measuring equipment are not fast enough to measure the magnitude of the rise in combustibles. Although the forementioned conditions exist, it has been found that the furnaces are sharper and are much faster with the reduction in fuel off time. This is borne out by the fact that it is necessary to slow down the reversals on furnaces with new roofs so that they will not be damaged.

FUEL SUMMARIZATION

During recent years the need has developed for an automatic control which will summarize two and in some cases three fuels. The nature of this control would depend upon the operating conditions in a given plant, but probably would be one in which the secondary fuel is used on an "available basis."

There are three general types or methods of performing the computations involved in summarizing the different fuels to be used. These are electrical, mechanical and pneumatic.

The mechanical system has demonstrated the greatest reliability, but this system requires more forward thinking and does not lend itself to modification as well as the other two systems.

The electrical system of fuel summarization is the latest development in this field and one which has a very promising future due to its versatility and high degree of accuracy. To date this system has not been generally accepted by industry and it is impossible to draw any definite conclusions at this time.

The pneumatic system of fuel summarization is one of the most popular types of control now in use. Time does not permit a discussion of the various methods employed by different control manufacturers who use compressed air in the totalizing of fuels.

Each system has its advantages and the merits of each must be judged by the individual application.

STEAM-OIL RATIO CONTROL

Steam-oil ratio control of the atomizing steam on an open hearth furnace has been open to a considerable amount of discussion. In most cases the controversy has settled around the proper temperature and pressure of both the oil and steam as to which produces the most desirable flame characteristics, temperatures and fuel efficiency. Basically the use of atomizing steam is for one purpose and that is to break up the liquid fuel into as many small particles as is possible and thereby permit more rapid mixing with air for combustion.

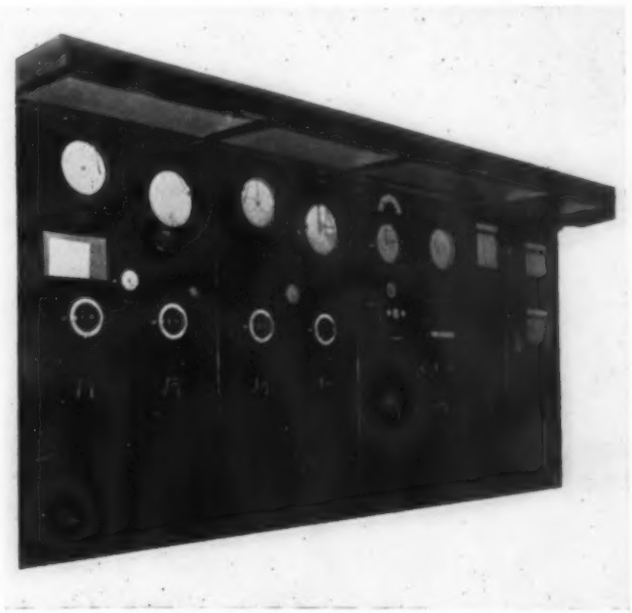
Tests have shown that with the oil viscosity stabilized by temperature, the maximum flame radiation and temperatures can be obtained by control of the steam volume rather than steam pressures. Generally speaking, using 2.5 to 3.5 lb of steam per gal of oil produces the maximum desired flame characteristics.

Some furnace operators prefer to use the same amount of steam regardless of the volume of oil being used. This practice is undesirable, especially in plants using mixed fuels such as gas and oil. Flame temperatures are lowered when an excessive amount of steam is used and the volume should be directly proportional to the oil being used.

FLAME RADIATION

The use of flame radiation measurements in open hearth operation has come in for its share of discussion. There is no doubt that any means which could be developed to continuously measure and control a flame at its maximum radiation would be of the utmost value to the industry. To date, no practical means has been

Figure 1 — General view of automatic control panel used on 200-ton tilting open hearth furnace which is fired with Bunker C oil and natural gas.



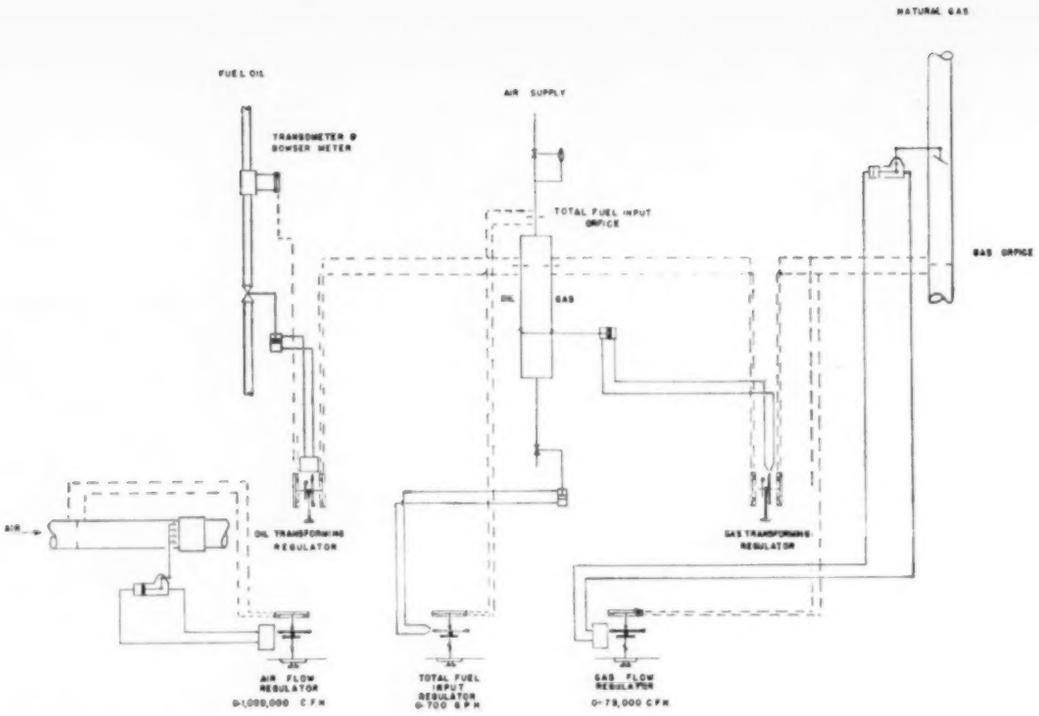


Figure 2 — A pneumatic type summarizer is used on this furnace.

developed whereby a reliable continuous measurement is available.

In our plant we use flame radiation measurements in setting the burner and determining the correct oil-steam ratio.

OPEN HEARTH FURNACE CONTROL

Figure 1 is a general view of the automatic control panel used on the furnace at the South Chicago plant of Republic Steel Corp. These are 200-ton tilting open hearths fired with Bunker C oil and natural gas. Oil is supplied to the furnace at 200 psi and at 170 F. Natural gas is used on "as available" basis with 19 psi at the heel of the burner when firing 75,00 cfh.

On the left side of the panel is the furnace pressure control and recording pressure gauge. This regulator is arranged to operate an oil cylinder and louvers on the inlet to the induced draft fan after the waste heat boiler. A variable speed fan has been provided to keep the louvers in an operating range regardless of furnace conditions.

Adjacent to the furnace pressure control is the total fuel input control and oil flow meter.

The summarizer used in this system is a pneumatic type, illustrated in Figure 2 and operates as follows: Clean, dry compressed air is supplied to the system through pressure regulators which maintain the static air pressure constant. The total quantity of air through the system is directly proportional to the total fuel input and is controlled by a regulator set by the first helper for the desired firing rate. A second regulator controls the volume of gas to be used and directly operates the gas flow control. The same differential impulse from the gas orifice is applied to the gas transforming regulator, which in turn changes the position of the valve in the gas side of the splitter until the two measuring systems on the regulator balance each other. The two valves in the splitter are mechanically linked so that when one valve opens the other closes. The position of the two valves is the ratio of oil to gas and the quantity of air through these two legs is equal to the total air flow through the system.

The oil transforming regulator receives its impulse from the oil side of the splitter and from the transometer in the oil line to the furnace. Oil is added in quantities sufficient to bring the total fuel input up to that desired, at which time the two impulse systems on the oil transforming regulator are in balance. Any change in the quantity of gas being delivered to the furnace is instantly reflected in the impulse to the gas transforming regulator which in turn repositions the splitter valves, increasing or decreasing the oil flow until the desired firing rate is re-established.

All of the control dials and flow meters can be calibrated in gallons of oil or oil equivalent or in thermal units, whichever is desired.

The flow meters are independent of the control system making it possible to operate the furnace manually and still indicate and record the fuel being used.

The air flow control is used to meter and control the desired volume of air for combustion. This unit operates louvers on the inlet to the forced draft fan receiving its primary impulse from an orifice plate on the fan inlet.

The gas flow control and combination gas flow and total fuel flow meter are on the right side of this section

of panel. Gas flow as well as total flows are calibrated in gallons of oil equivalent.

The right hand section of the panel contains the steam pressure control, steam pressure and flow meter, oil temperature control and the furnace reversal controls.

The reversal system is a combination electrical, pneumatic and hydraulic operation and performs the following functions in sequence:

1. Closes the fuel control and fuel reversal valves and the steam valve slowly, simultaneously opening the stack damper and the louvers on the forced draft fan.
2. Reverses the flue dampers and combustion air valves.
3. Opens fuel and steam reversing valves and at the same time opens wide the steam flow control valve.
4. After a preset time interval for purging the waste gases from the checkers, oil and gas flow control valves, stack damper and fan louvers are placed under control by their respective regulators.

The sequence of control may be accomplished by any one of three methods:

1. Automatically from the temperature difference controller or by a fixed time cycle.
2. Push button, a manual-electrical means of reversing the furnace at the discretion of the first helper.
3. Manual, by operating manual reversing fuel valves and electrically operating flue dampers and combustion air valves.

All of the fuel reversing valves are electrically interlocked, making it impossible to fire both ends of the furnace at one time.

CONCLUSION

The automatic control system on an open hearth furnace is one of the best examples of correlating the functional operations with the many variables affecting furnace performance. Automatic reversal and control of the fuel, steam, air and furnace pressure has improved refractory life, lowered fuel rates, eliminated the element of human error and increased production and product quality. There is no doubt that additional advantages are to be had when the other variables are brought into line and held constant. In fact, it is not at all inconceivable that the day will come when all of the variables are controlled and the fueling of the furnace will be accomplished through use of a program device.

Experience has been an excellent teacher, and during the past few years in which the development and application of controls has progressed so rapidly we have learned that the old rule of thumb methods can no longer be applied. Control engineering has become one of the newer sciences which must be based upon analytical methods with certain fundamental laws and principles. These are good control layout and planning, an effective program of preventive maintenance, and the full cooperation of supervision and the men who are to use the controls. Without all three of these factors the prime purpose of the automatic control, which is efficiency and economy, cannot be attained.

"FUEL OIL ATOMIZATION WITH NATURAL GAS"

By W. A. PETERS, Chief Metallurgist

Laclede Steel Co.

Alton, Ill.

▲ ATOMIZATION of No. 6 or "Bunker C" fuel oil with relatively high pressure natural gas for open hearth combustion is, from our viewpoint, entirely practical and economical. The resulting flame melts scrap as rapidly as we can charge it into the furnaces and although we have never attempted to either measure nor to calculate flame temperature, we believe from the speed with which melting occurs compared to our previous practice with steam atomization, that the resulting flame is hotter. There is nothing spectacular about the appearance of this flame, to say it is a good flame is about the best way to describe it.

We are at present receiving our gas at 30 psi pressure and compressing it to about 250 psi in two, two stage compressors, each driven by 150-hp electric motors. These compressors are not equipped with either inner coolers nor after coolers. They are located at one end of the open hearth floor so that the gas temperature at the burner is approximately 225 F due to the heat of compression. This temperature we believe is necessary for good atomization, a deduction which we base on observation of the flame immediately following a gas curtailment before the compressors are fully warmed up. We are curious about the results from a higher temperature, of say 500 F but to date we have not tried anything.

We have four furnaces rated at 150 gross ton capacity. The maximum rate of fuel input during melt down is about 50,000,000 Btu's per hour. Of this approximately half is supplied by the atomizing gas reduced in pressure to 150 psi at the atomizer. When the heat is under cover the gas pressure is reduced to 120 psi and the oil flow increased about 30 gal per hour. This gives a somewhat longer and softer flame which seems to be better for pulling lime and shaping up the heat.

It should be brought out here, however, that while we feel that we have a superior flame when atomizing with hot, high pressure gas, we have no adequate comparison in our own shop with good steam atomization. We are lucky to get 100 psi pressure of warm water when on "so-called" steam atomization.

Our shop is normally a cold charge, high scrap shop. At present time we are charging about 65 per cent cold scrap and 35 per cent hot cupola iron. Our heat times average 11 hours and 30 minutes tap-to-tap and actual tons per operating hour slightly better than 13.5 net tons. Prior to the use of the gas for atomization, our fuel consumption averaged about 24 gal of oil per ton. It now averages about 14 gal of oil per net ton plus 1450 cu ft of gas.

We have no idea what our atomizing steam consumption amounted to, but we feel that it possibly cancels out the cost of compression of the gas.

We have noticed no appreciable increase in brick

erosion since going to this type of firing. We shut No. 3 furnace down the other day after 314 heats on the roof with no patching during the run.

Our furnace dimensions are as follows:

Burner length—72 in.

Burner inside furnace—53 in.

Uptake dimensions 6 ft–8¾ in. x 15 ft–3½ in.

There is just one large uptake. We do not have a block arch. Burner is artillery type, water cooled jacket.

Hearth length—40 ft–6 in.

Hearth width—15 ft–0 in.

Bath length—36 in.

Furnace length inside brickwork—63 ft–9 in.

"CONTROL OF MULTI-FUEL FIRED OPEN HEARTH FURNACES"

By R. G. BRYAN

Republic Flow Meters Co.

Chicago, Ill.

▲ ANYONE who has been around an open hearth shop where more than one fuel is fired at a time, appreciates the difficulties that are encountered in setting and enforcing a maximum firing rate schedule. Such a schedule should include all the various proportions of fuels which can be used to provide the desired maximum Btu input at the various stages of the heat. The necessity of following such a schedule adds complications to the job of the first helpers who may inadvertently violate it on occasion. The results of such mishaps are damage to furnace refractories, decreased roof life, and higher fuel costs. By the addition of an automatic fuel totalizing system, the problem is reduced to one involving little more complication than that which exists when burning a single fuel.

Since no two shops operate under exactly the same conditions, it would be impractical to set up one standard system which would exactly fit the needs of any shop in which it might be applied. Such considerations as the type and availability characteristics of the gaseous fuels used, existing control equipment into which the system must be tied, and the degree of automatic control desired, must all be taken into account. For this reason we have endeavored to present in Figure 1 a more or less typical system rather than any one particular existing system which we have in operation. This system, in whole or in part, is with various modifications in operation in several open hearth shops both here and abroad including one application in the Chicago district.

Referring to Figure 1 let us assume that fuel No. 2 is a gaseous fuel such as coke oven or natural gas which is to be manually controlled. This fuel is not always available and when it is, is not always available in the same quantity. The amount that may be burned at any one time will be determined by a plant fuel dispatcher or possibly by automatic devices which operate to cut gas on or off furnaces, as necessary, to hold gas pressure within the desired limits.

We will assume that fuel No. 1 is some fuel, such as oil, which is always available and is to be the make-up fuel.

The flows of both fuels are measured by the pneumatic flow transmitters connected across orifice plates or other primary devices. Time does not permit a description of these transmitters beyond stating that they are null balance instruments which produce "straight line" air loading pressures proportional to the flow of the fluid they are measuring. They shoud not be confused with the more common differential type of transmitter which produces air loading pressures proportional to differential pressure and, therefore, proportional to the square of the flow.

In each case, we have shown a recorder connected to the output pressure of the transmitter. These recorders are simple helix type pressure recorders, but read directly in terms of fuel flow on evenly graduated charts.

The output pressures from the two transmitters pass through $\frac{5}{16}$ in. outside diam copper tubing to a two-fuel totalizer which is illustrated diagrammatically. This device, briefly, is a balanced beam type instrument. It automatically produces an air pressure which, acting on a diaphragm on one side of the fulcrum, is of sufficient magnitude to balance the forces caused by the air pressure from the transmitters acting on diaphragms on the opposite side. The pressure which acts on the balancing diaphragms is the pressure sent out by the totalizer and is proportional to total fuel flowing, since it is equal to the sum of the two pressures from the transmitters. By the correct sizing of the diaphragms and their location from the fulcrum, the two fuels can be reduced to their common denominator which is, of course, Btu.

Since the loading pressure sent out by the totalizer is proportional to total Btu input to the furnace, it is only necessary to impress it on a helix type pressure recorder in order to produce a straight line, evenly graduated, record of this total Btu input.

A manual loading valve with a hand knob is provided on the instrument panel by means of which the first helper can send out air loading pressures to a total Btu regulator. This regulator also receives the air loading pressure from the fuel totalizer, balances it against the pressure from the hand loading valve and moves the fuel No. 1 control valve as necessary to maintain this balance.

Thus, if the first helper desires to put more fuel on the furnace he turns the hand knob on the manual loading valve to increase the air loading pressure going to the regulator. The regulator will then increase the flow of fuel No. 1 until sufficient fuel has been added to cause the pressure from the totalizer to build up enough to again balance the pressure from the manual loading valve.

If, for any reason, the flow of either fuel increases or decreases, due to a change in pressure of the fuel or in the case of fuel No. 2, to a change made manually by the first helper, the output pressure from the totalizer will be immediately affected. The regulator will either increase or decrease the flow of fuel No. 1 as required, in order to restore the output pressure from the totalizer to its original value and thus maintain the same total Btu input to the furnace.

To complete the system, a manual to automatic sta-

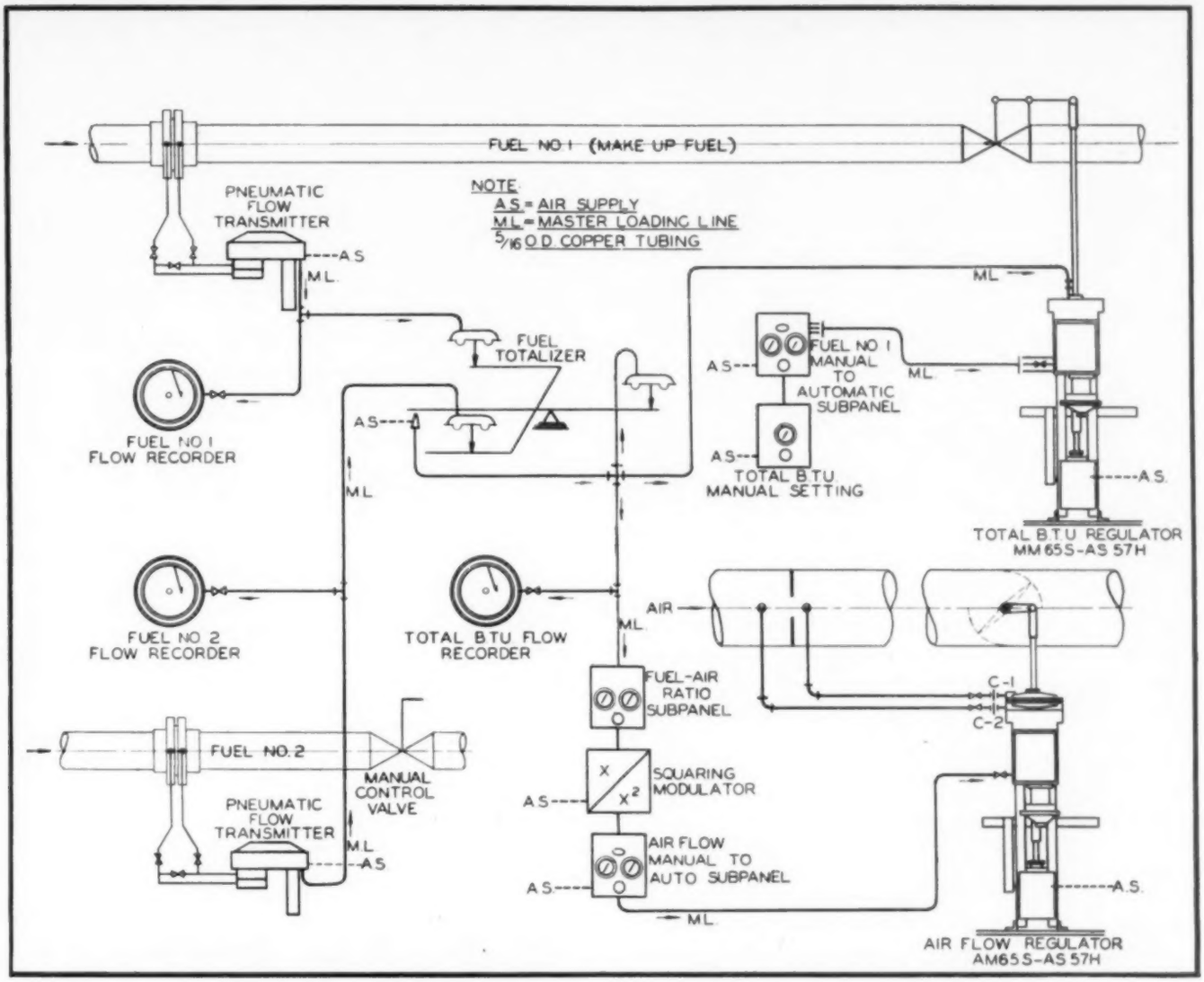


Figure 1 — Typical multiple fuel control scheme is shown in this diagram.

tion has been provided to enable the operator to take over manual control of the fuel No. 1 regulator at the instrument panel, if desired.

Since we have an air loading pressure from the totalizer proportional to total fuel, it becomes a simple matter to provide fuel air ratio control. It is, of course, necessary that we mathematically square this pressure in order to change it from a pressure proportional to flow to one proportional to total fuel flow differential. This is accomplished by a squaring modulator which sends out a pressure equal to the square of any pressure which it receives. This pressure is balanced on a regulator against air flow differential as measured across an orifice plate in the air duct. The regulator moves the air butterfly, as required, to maintain this balance. The two subpanels ahead of the regulator are a ratio subpanel and a manual to automatic station, both mounted on the instrument panel.

If desired, a transmitter could be supplied to measure the air flow. If this were done, the air flow regulator would become identical with the fuel No. 1 regulator. It would also be possible to add a second pen to the total Btu flow recorder and produce a "straight line" record of total Btu and air flow on the same chart.

It should be noted that this particular fuel-air ratio system is applicable only to two fuels which require close to the same amount of air for equal Btu release. In the case of two fuels which do not follow this rule, such as blast furnace gas and oil, we would add a second totalizer to the system. This totalizer would be connected to the same two transmitters, but would be set up on the relative air requirements of the two fuels rather than on their relative heating values. The output loading from this totalizer would load the air flow regulator.

The system illustrated is a fully measuring type system. It is very flexible and can be integrated with some slight modification into existing equipment, either of our own or other manufacture. The basic equipment can be combined in many ways to control a great variety of functions. As an example, the system illustrated would apply equally well to the totalizing of air and oxygen flow to an open hearth furnace.

"FUEL-AIR RATIO CONTROLS FOR THE STEEL INDUSTRY"

By L. H. COLEMAN, Field Engineer
Leeds & Northrup Co.
Chicago, Ill.

▲ IN step with developments in steel mill operations we are glad to discuss some relatively new equipment which has kept pace with the advancements in mill process and practice.

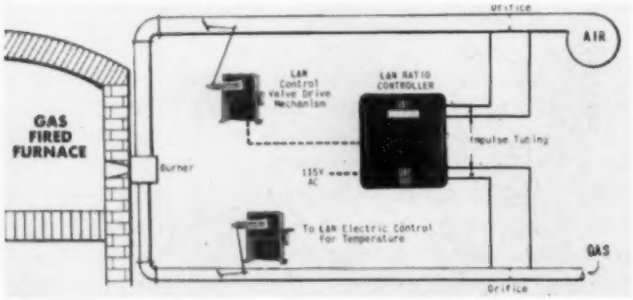
The equipment constitutes a fuel-air ratio system that incorporates the same basic principles employed in our temperature control system which are broadly accepted and successfully applied in the steel industry. The control is available in both the electric and pneumatic types, each provided with proportional band and reset action which permit tuning the control system to widely varying operating conditions.

Figure 1 shows diagrammatically the application of the electric type fuel-air ratio control to a typical gas-fired furnace. Figure 2 is a similar fuel-air ratio system for a typical oil-fired furnace. The diagrammatic layouts for pneumatic control are similar to Figures 1 and 2 except pneumatic valve operators replace the electric type.

Figure 3 shows schematically the principle of operation of both the electric and pneumatic fuel-air ratio controllers. In the electric type the fuel-air ratio differential unbalance establishes an electrical measure proportional to the ratio unbalance, which serves to operate a valve drive unit to return the fuel-air ratio to balance. The same occurs in the pneumatic system except an air pressure is established proportional to the fuel-air ratio differential unbalance. These functions are accomplished through the use of the same control components which are a part of our standard temperature controls.

Figures 4 and 5 show the accessibility and ease of removing the various control components for maintenance purposes. Figure 6 illustrates a typical complete integrated control panel including temperature, furnace pressure and fuel-air ratio control.

Figure 1 — Application of electric fuel-air ratio control to gas fired furnace.



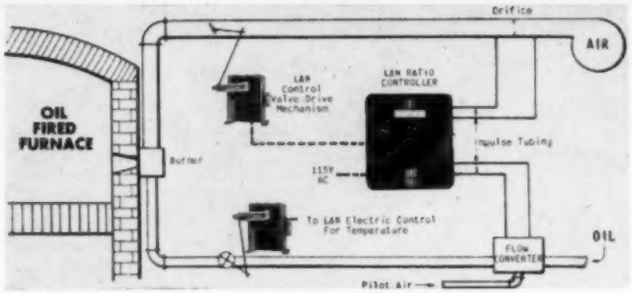


Figure 2 — Application of electric fuel-air ratio control to oil fired furnace.

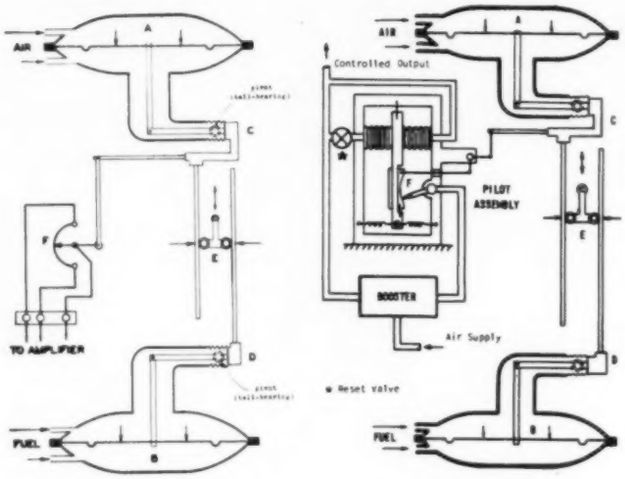


Figure 3 — Sketch shows principle of operation of electric and pneumatic fuel-air ratio controller.

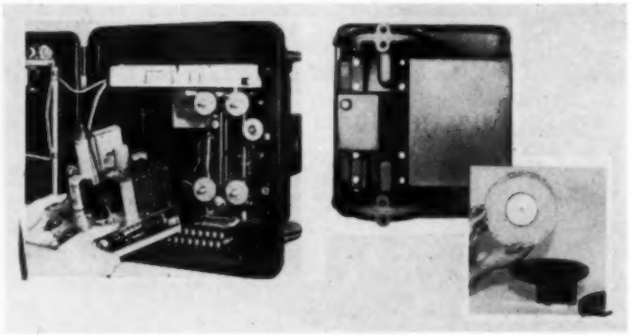
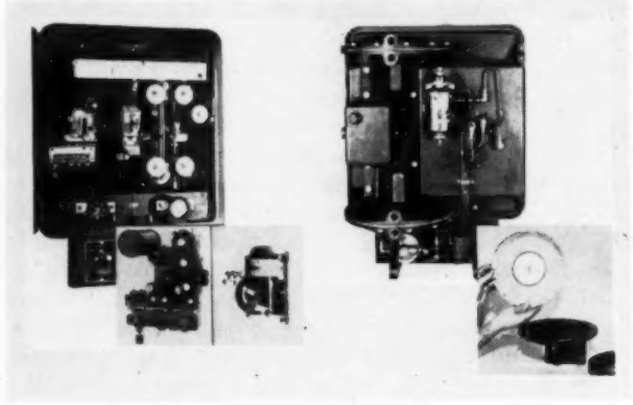


Figure 4 — Ease of removing control components is here illustrated.

Figure 5 — Access to control components is very simple



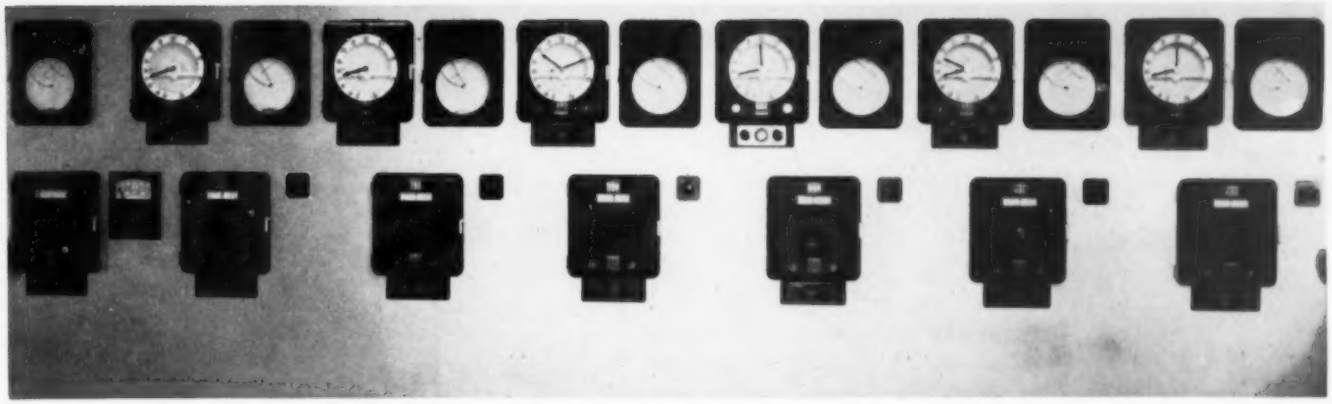


Figure 6 — This completely integrated control panel includes temperature, furnace pressure and fuel-air ratio control.

"BTU CONTROL"

By S. H. JONES, District Manager

Askania Regulator Co.

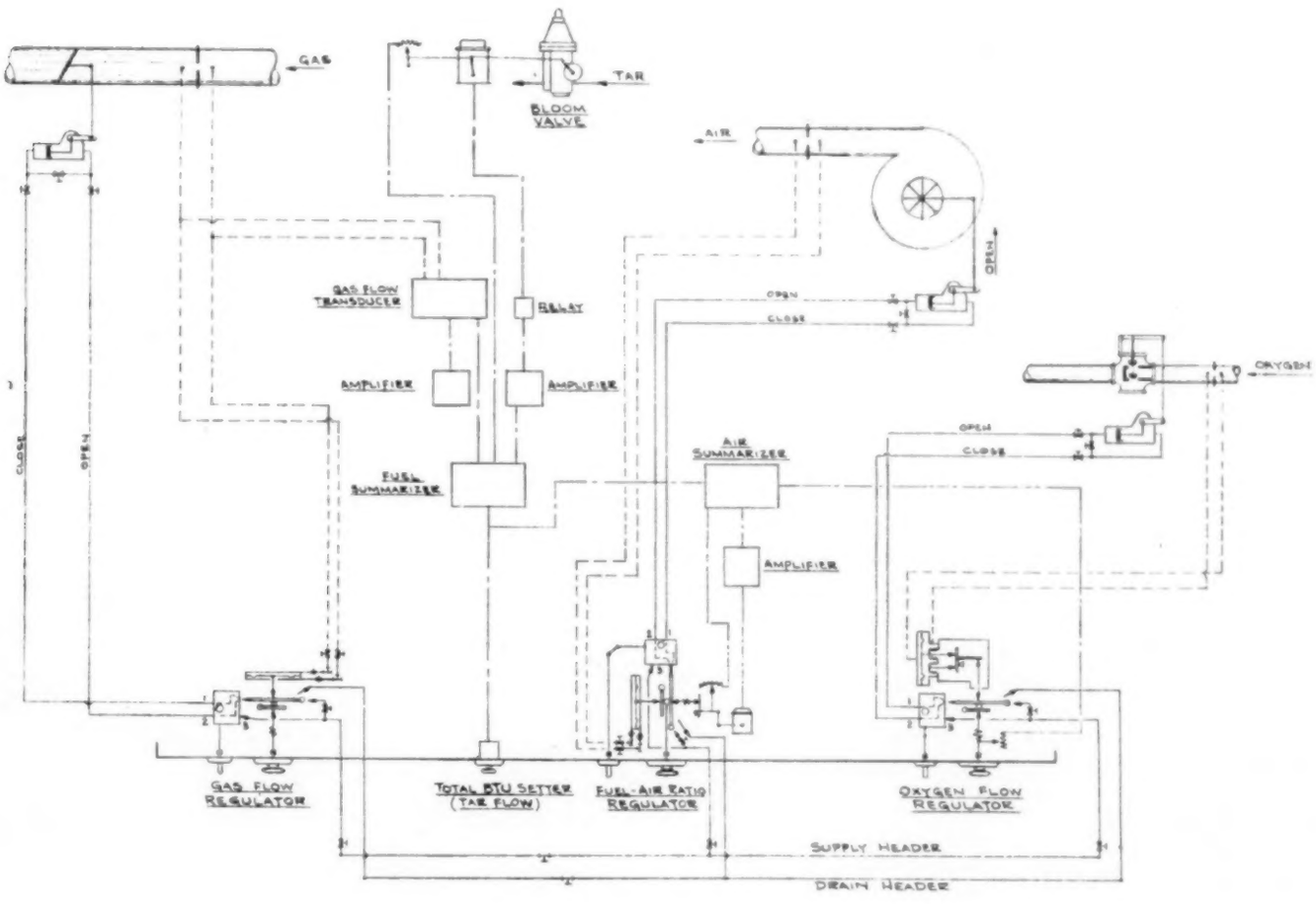
Chicago, Ill.

▲ IN setting the design of a Btu control system we have two basic beliefs as guides. The first axiom that we believe in is that separate control and separate recorders should be provided. We believe this because we have found that if the first helper is dependent upon one single system, failure of that system is a distinct handicap. By keeping the control separate from the recording system, failure of either system still leaves the first helper with some tools with which to work.

Our second axiom is that simplicity breeds low maintenance. To us this means that we must avoid all complexities possible. We endeavor to eliminate as many transforming relays, transducers and similar devices as possible.

We generally start the design of a Btu control system with a regulator for each of the variables going into the furnace. We then design a computing mechanism that

Figure 1 — The impulse diagram for a Btu control system.



assists the first helper in setting the various flows into his furnace. This adding machine or computing mechanism has been found to vary considerably between various installations in various plants.

We have found that one particular plant has a problem that can be most easily solved with a mechanical adding machine while other plants require pneumatic or electrical types.

MECHANICAL SUMMARIZATION

The mechanical adding machine has proven to be the most dependable since we can make the component parts of the adding machine out of heavy cast iron. Once we have calibrated such a machine there is less difficulty in maintaining the calibration than with the other two types.

Unfortunately, however, in the design of this adding machine we must take into account all of the future requirements of the installation, because it is very difficult to make alterations once the machine is built.

PNEUMATIC SUMMARIZATION

The pneumatic type of summarizing equipment has been in use for a great number of years. It will not hold its calibration quite as well as the mechanical summarizing equipment, but it is far easier to alter or modify in line with the newer developments of automatic control.

It is extremely desirable that the air used in the pneumatic system be as clean as possible, although the valves and orifices involved are relatively large and do not give the same degree of trouble as a conventional air operated relay.

ELECTRICAL SUMMARIZATION

The electrical adding machine is the newest type being offered today. It has established excellent reliability and it is the easiest to modify to take care of changing plant conditions.

As you can see on Figure 1, slide wires are provided which develop voltages proportional to the set point of the various controls, and which are interconnected with or familiar simple regulators to control the variables of the furnace. The set point of the regulators are carried to a resistance net work which totalizes the flows involved to give a signal for setting the combustion air regulators. In order to add oxygen and cut back the air proportionately, a simple regulator is provided for controlling oxygen flow and a signal is sent to a net work to cut back the air flow.

In conclusion, when we adhere to our two basic axioms for design of Btu control, we usually find one of the three systems fits a particular job better than the other two.

We seldom have to compromise our two axioms if we select the proper adding machine.

"CONTROL SYSTEMS FOR IMPROVED OPEN HEARTH OPERATION"

By JOHN R. GREEN, Manager Steel and Ceramic Division
Brown Instruments Division
Minneapolis-Honeywell Regulator Co.
Philadelphia, Pa.

▲ SEVERAL relatively new instrument designs are available to provide (as illustrated in Figure 1) additional convenience and flexibility in the control of firing or ratio control to open hearth furnaces.

The basic design shown here for measurement of oil or tar, steam, and gas flows is an instrument, which provides continuous recording, large scale indicator, and direct reading totalizer. The addition of automatic control, complete manual operation from the instrument, remote transmission of actual flow for totalizing or ratio purposes, as well as remote manual or automatic setting of the control index, can all be incorporated into the single instrument design.

In the schematic diagram shown, several of these facilities are employed to provide the following functions, in addition to positive and accurate metering and integration.

1. Individual automatic control of oil and gas flow.
2. Summation of actual total fuel flow (regardless of control settings) for the automatic control of air flow at any present ratio. A large dial indication of both total fuel and air flows may be provided for the first helper by a two pointer gauge, as well as permanent records of both on the control instrument.
3. Steam flow is automatically proportioned to the actual oil flow at any preset ratio.
4. Any or all of these flows may be placed on manual control at the corresponding instrument, and returned to automatic operation without upsetting the process. The instruments may be serviced, or removed if necessary, without interfering with such manual operation.
5. The readmission rates of all flows during or following reversal are individually adjustable, but automatically actuated from the furnace reversal operation.

Several alternate connections or methods of operation are obvious, such as:

1. Alternate electrically switching to meter bodies handling oil and tar or pitch, the single instrument being calibrated in oil equivalent.
2. Additional scale on gas flow meter, reading equivalent gallons of oil.
3. Ability to provide automatic makeup by either fuel, from total Btu controller.
4. Automatic control of air volumes without ratio to fuel.
5. Ability to include any portion of gas flow into the

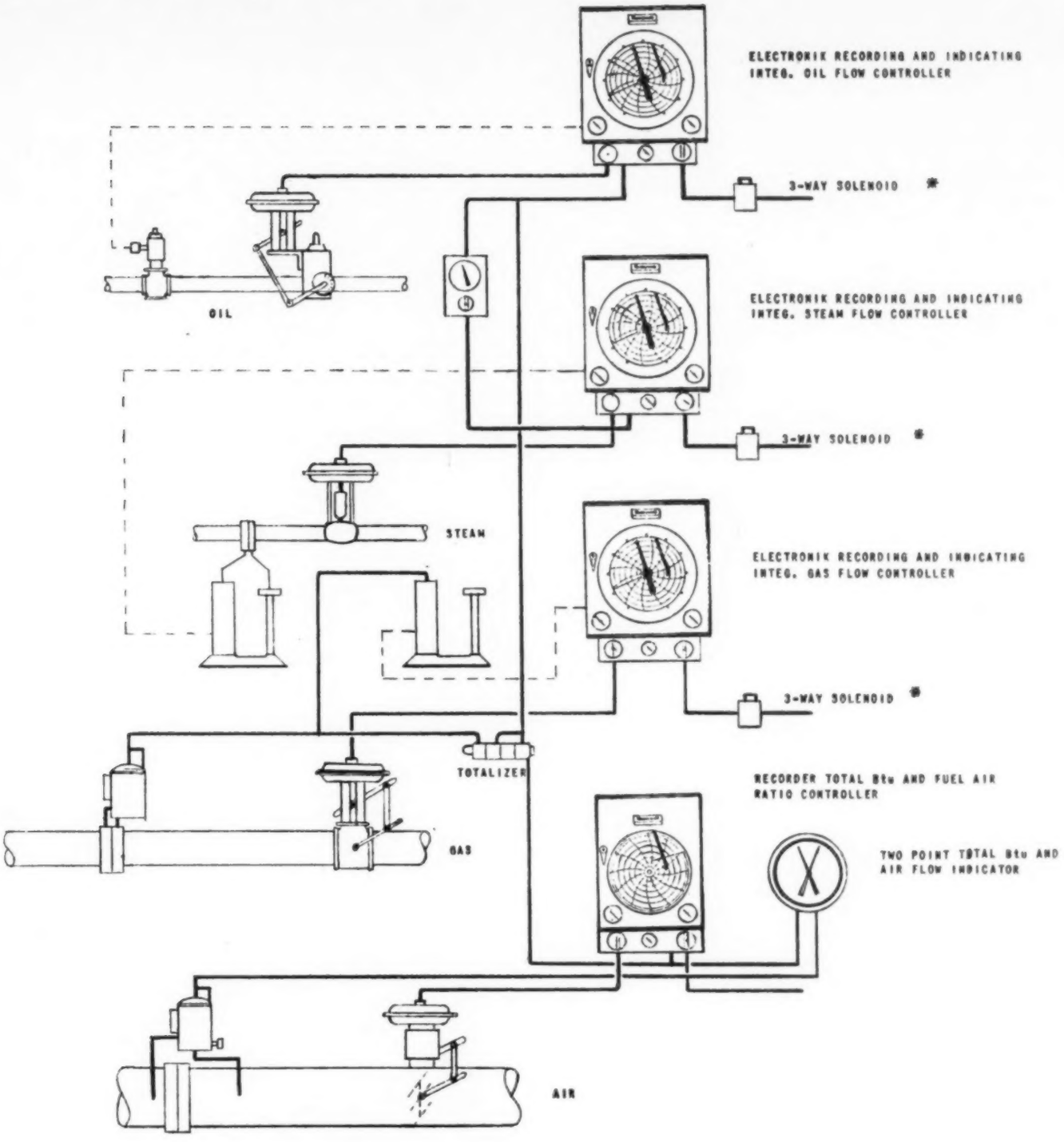


Figure 1 — In this control scheme, on start of reversal 3-way solenoids on fuel valves bleed out and provide fast valve closure. Solenoid on combustion air bleeds fast to open air louvres fully for furnace purge. Solenoid on stack damper can be connected to lock damper in position during reversal or to have damper travel slowly toward open position. When reversal is completed, supply air to fuel valves are passed through adjustable restrictions providing controlled rate of fuel readmission. Supply air to combustion air louvre operator is reestablished to previous setting.

steam ratio, for the purpose of controlling flame pattern.

6. Remote settings of all flows or ratios can be established from a compact console when instruments are mounted in a conditioned room with glass front.
7. Automatic trimming of fuel-air ratios from exit gas oxygen analysis.

The more conventional instrumentation of open hearth furnaces include:

1. Furnace pressure control, which usually includes

some artificial but automatic action during reversal. Future installations may advantageously reset controlled pressure as a function of fuel flow.

2. Checker balance and heat level conditions are recorded, preferably as top checker temperature by means of radiation units.
3. Reversal may be initiated, either manually from signals or automatically, from a combination of:
   a. Maximum time (during charging and melt down).
   b. Temperature difference. (When based on radiation, provides an automatic shortening of cycle during finishing stages of the heat).
   c. Maximum temperature of heating checkers.

   Simple interlocked systems for the operation of reversal in fastest sequence can be provided.
4. Roof temperature measurements, for either signalling or automatic trimming of fuel, are increasingly important with high tonnage rates. Simple automatic means for selection of highest temperatures from two or more locations are now available.

Additional combustion facilities can be provided, including the following modifications:

1. Setting total Btu input from a single manual loading station.
2. Automatically supply liquid fuel to a minimum fixed per cent of total desired fuel flow.
3. Supply gas up to a preset maximum percentage of total fuel, which is automatically limited by coke oven gas availability.
4. Automatically make up to total fuel setting by additional oil flow.

The air flow control system can be further modified to perform the following functions:

1. Compensate for air infiltration, as determined by periodic gas analysis, and as a function of total fuel flow.
2. Trim this compensation, as required, for each end of furnace upon its reversal.
3. Provide any preset excess air on a timed basis from push button operation.
4. Provide oxygen for combustion as required (in air equivalents) beyond either a maximum preset fuel rate or air availability.

Such interlocked systems of control, complex as they may appear at first glance, provide the means of securing lower Btu per ton, shorter time of heat, or resultant increase in tons per hour—without sacrificing the flexibility of automatic or manual regulation of each variable whenever desired.

"MODERN OPEN HEARTH CONTROL"

By HARRY MORTON

Hagan Corp.

Chicago, Ill.

▲ WE feel that under present day operation, the control system for an open hearth should be extremely functional with emphasis placed on simplicity of operation and accuracy of control of all components having to do with control of fuel or fuels, atomizing mediums and enrichment of any of the basic ingredients being fed to the furnace under normal operation. Figure 1 shows a system of control diagrammatically as is being used at the present time on many open hearth furnaces throughout the country. This system of control controls two fuels, namely oil and tar, and also controls steam flow for atomization purposes. Coupled therewith is a control for combustion air in proportions necessary for the fuels being fired. As an auxiliary adjunct, the control system is also set up to control oxygen to the furnace, being used for the purpose of air enrichment.

The left center of the diagram shows a total fuel relay which controls, primarily, Btu input for total Btu to the furnace. This relay automatically controls the flow of fuel oil to the furnace in proportion to the set requirement. On the upper left is a tar control relay, controlling the flow of tar to the furnace in whatever proportion is set. The control system automatically reduces the amount of oil being fired simultaneously with the tar, in whatever proportion the tar is added thereby; always controlling the total Btu input to the furnace.

Superimposed on this control is a roof temperature recorder controller. The function of this controller is to cut back, under modulating control, the amount of fuel necessary to hold the furnace below the danger point which has been predetermined as being detrimental to the roof. Steam for atomizing both oil and tar is controlled proportionately for each fuel in accordance with the set ratio. Both fuels are totalized and the resultant impulse is sent to a combustion air flow relay which controls the admission of combustion air to the furnace.

In the lower left hand corner of the diagram is shown an oxygen relay. This relay controls the flow of oxygen to the furnace in whatever amount it is set for and this oxygen is used, in this case, for enrichment of combustion air. The combustion air flow control system is so arranged that any amount of oxygen fed to the furnace for air enrichment is automatically subtracted from the total air and the air flow controller regulates the combustion air to a lower flow so that the total oxygen to the furnace, both from combustion air and pure oxygen feed, is always correct in the amount necessary for the fuel being fired.

For reversal of all components on the furnace, there is shown, upper center in the diagram, a reversal unit. The type of unit used for this service varies according to the dictates of the various plants in which our open hearth combustion control system is used. Furnace pressure is controlled by manipulating the outlet damper of the waste heat boiler or operating the slide damper in the by-pass around the waste heat boiler for such times as the waste heat boiler might be out of

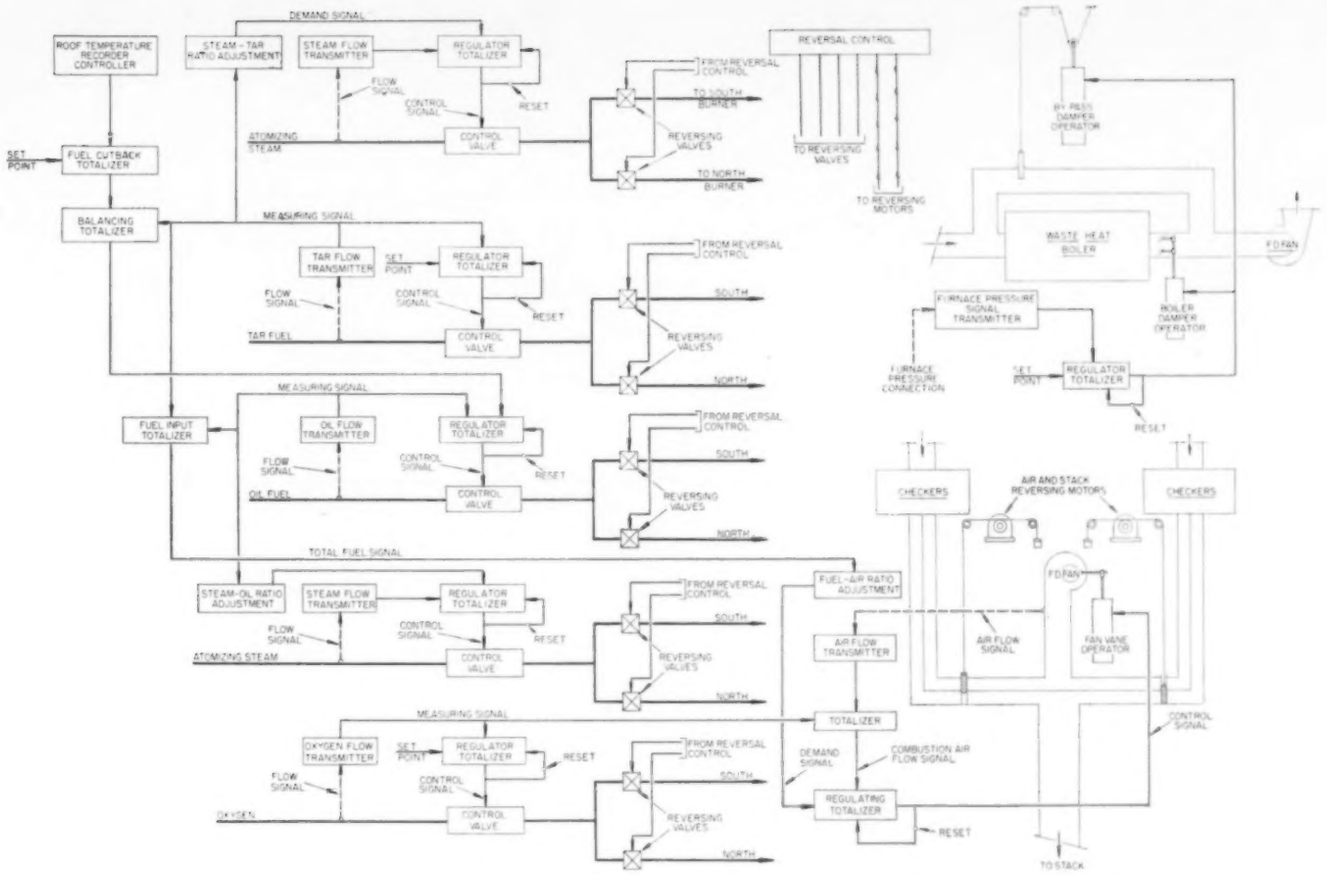


Figure 1 — Another typical control scheme for an open hearth furnace is here shown.

service. While under usual circumstances, there is a great deal of disparity between the operation of an outlet damper for a waste heat boiler and a slide type of damper, these are compensated for in our control system by shaping the long contour bar of each of the power units. This is one of our basic features.

In addition to all of the control components as discussed heretofore, there is provided meters and indicators for every phase of the operation in order to form an integrated system of control and instrumentation to be used as a tool by the operator in the production of steel. Each large face indicator has both a set-point pointer, as well as a flow or control pointer, so that the operator knows at all times whether or not the controlled components of the system are operating properly. These indicators can be seen across the charging floor if necessary, and we feel they are necessary for successful operation of any open hearth.

AID DEFENSE

MORE SCRAP TODAY . . . .

MORE STEEL TOMORROW.

GET IN THE SCRAP TO KEEP STEEL COMING.

NON-FERROUS SCRAP IS NEEDED TOO!

INCREASED INTERRUPTING CAPACITY IN FUSES

. . . . the dual-element fuse offers interesting possibilities for protection of steel plant electrical circuits . . . .

By JOHN C. LEBENS
Chief Engineer
Bussmann Manufacturing Co.
St. Louis, Mo.

▲ ORIGINALLY the sole function of the low voltage fuse was the protection of circuits against heavy fault or short-circuit currents. Such fuses had very low thermal capacity so that once the current exceeded their rating they blew rapidly. Because of this lack of time-lag, it was necessary to select the fuse size large enough so that it did not blow under ordinary, harmless transient conditions produced by the starting of motors, switching of capacitors, or other momentary overloads. Hence the fuse was capable of giving only short-circuit protection, and overload protection required an additional device such as the thermal overload relay.

In 1930 the basic fusing philosophy was jolted by the conception of building a protective device in the standard fuse dimensions having sufficient thermal capacity to carry the low overloads as long as the wiring and associated equipment were not injured, but which would open to clear the circuit if these overloads continued beyond a safe time. In other words, the time-current characteristic of the fuse should be matched to the safe time-current characteristic of the electrical equipment so that the fuse only will blow when a dangerous condition develops.

Under normal, satisfactory operating conditions, the current can vary within extremely wide limits without injuring the equipment as long as the current is not permitted to flow longer than a predetermined, safe time. Under faulty, or dangerous operating conditions these same currents are maintained long enough to damage, if not destroy, the device. The demarcation between satisfactory and faulty operation is a matter of time at any particular value of current. If the current is cut off before damaging conditions are reached, the electrical machine is not being operated at its full capacity, whereas, if the current is allowed to continue too long, the machine is destroyed. Hence, for complete protection, the time-current characteristic of the protective device must be matched to the safe time-current characteristic of the electrical equipment. Otherwise little more than short-circuit protection can be guaranteed.

The safe time-current characteristic of an electrical machine is a function of its three component parts namely, the current conducting path, the electrical insulation, and the heat absorbing mass. In an electric motor the current conducting path is the copper wire; the electrical insulation is the enamel, silk, cotton, glass, or the like; and the heat absorbing mass is the iron in the rotor and stator of the motor. Although the motor provides a convenient illustration, any electrical device consists of the three fundamental parts of current conducting path, insulation, and heat absorbing mass.

On the low overloads which can be withstood for relatively long periods there is time for heat conduction. Under this condition the temperature of all parts of the equipment is elevated by the heat generated in the current conducting path. The rate at which the temperature is increased is inversely proportional to the mass of the heat absorbing member and to the amount of heat lost by radiation and convection and, of course, is directly proportional to the amount of heat generated. All three component parts heat up as a unit and failure occurs when the damaging temperature of the least heat resistant material is reached. This usually is the electrical insulation.

Since the heat generated is proportional to the square of the current, the safe time of the equipment steadily decreases as the current is increased, the shape of the safe time-current characteristic being approximately a square law curve. The curve actually varies from a true square law curve by a factor unique for each machine being dependent upon its thermal conduction, radiation, and thermal capacity.

As the current is increased, a point finally is reached where the heat generated in the electrical path is so great that the wire itself melts before any or little of the heat can be conducted from it. At these very high

overloads or short-circuits an extremely short safe time results. Since there is little time for thermal conduction, the heat absorbing mass is that of the wire itself. Therefore, the shape of the safe time-current characteristic curve at these overloads is a square law curve having an extremely steep slope.

Hence the ideal protector should have ample time-lag at the lower overloads to obtain maximum capacity from the associated equipment, but virtually no time-lag under short-circuit conditions to clear heavy fault currents so rapidly that they will be limited to nominal values, incapable of injuring the circuit wiring or the electrical equipment.

The dual-element fuse shown in Figure 1 represents the culmination of the development started by this conception of the ideal electrical protective device.

It consists of a short-circuiting strip surrounded by arc-quenching filler in each end of the fuse with a thermal overload device in the center. Current flowing through the fuse generates heat in the short-circuiting strips. At the lower overloads where there is time for thermal conduction, the heat is conducted into the themal overload device in the center of the fuse raising its temperature to 280 F at which point the fusible alloy melts permitting the interrupter to move mechanically, under spring tension, opening the circuit. At the higher overloads, where there is no time for thermal conduction, the heat generated in the weak spots of the short-circuiting strips raise their temperature to the melting point causing them to operate like ordinary fast acting fuses.

By combing a thermal cutout with a fast acting fuse link in the same fuse case, sufficient time-lag can be built into the device to eliminate needless blowing on harmless overloads and still obtain fast action under short-circuit conditions. This is shown in Figure 2. The comparison between the dual-element fuse, the ordinary one-time fuse and the air circuit-breaker clearly shows the effect of the thermal cutout of the dual-element fuse on its time-current characteristic.

All three devices have the same current rating. In other words all three are capable of carrying 100 amperes indefinitely and all three will open at 135 amperes in approximately the same time. However, from this common starting point the characteristics of the three devices diverge as shown. The ordinary one-time fuse, having relatively little thermal capacity and only one mode of operation, has a smooth time-current characteristic without any points of inflection. It has little time-lag at the lower overloads so that it will open on harmless transients. Even so it is slower than the dual-element fuse under short-circuit conditions. The curve is cut off at 10,000 amperes because tests have not been conducted at higher fault currents.

The air circuit-breaker has more time-lag than the ordinary one time fuse at the useful overloads. Up to 1000 per cent load the bimetal trip operates the breaker so that the thermal capacity of the unit affects its time-current characteristic. At 1000 per cent load the magnetic trip comes into play causing the curve to drop off rapidly to a time equal to approximately one cycle which represents the minimum time of opening of this type circuit-breaker.

The dual-element fuse has even more time-lag at the useful loads, but at fault current it drops to an amazingly short time which requires the introduction of a new concept to understand completely. It will be noted that the abscissa and the ordinate axes of the curves in Figure 2 are labeled "Virtual Time" and "Prospective Current," respectively. These terms, which almost certainly will be endorsed by the International Electrotechnical Commission, become necessary to establish exactly what is meant by current and time with reference to the fuse operation at times less than 0.01 second.

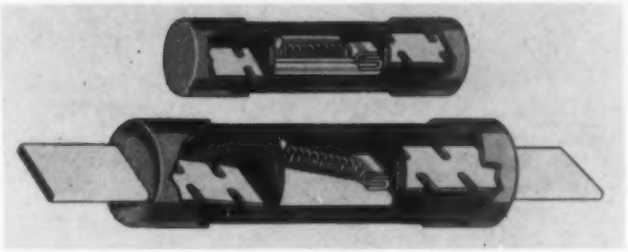


Figure 1 — Cut-away section of 60 and 100-amp, 250-volt dual-element fuse.

Until recently the only short-circuit tests conducted by unbiased laboratories on low-voltage fuses were those of the Underwriters' Laboratories, Inc. on direct current with only 10,000 amperes available. The criterion as to the success or failure of the fuse on these tests is the actual physical condition of the fuse after the test and whether it created a fire hazard in clearing the circuit. Oscillograms are not made so no actual values of time or current are available.

Even if such data were taken, the results obtained on the d-c circuit of the Underwriters' Laboratories give little indication of the performance of the fuse on a-c circuits capable of delivering 50,000, 100,000 and 150,000 amperes. Even though field experience with fuses has been unusually successful, the responsibility placed on the shoulders of the circuit designer specifying fuses without complete interrupting test data was so great that many hesitated to use them for applications where high fault currents were available. If the system required the coordination of the protective devices, data on the performance at the high fault currents was mandatory.

To obtain this data, tests witnessed by the Electrical

Figure 2 — Comparison of time-current characteristics of 100-amp dual-element fuse, ordinary fuse, and air circuit-breaker.

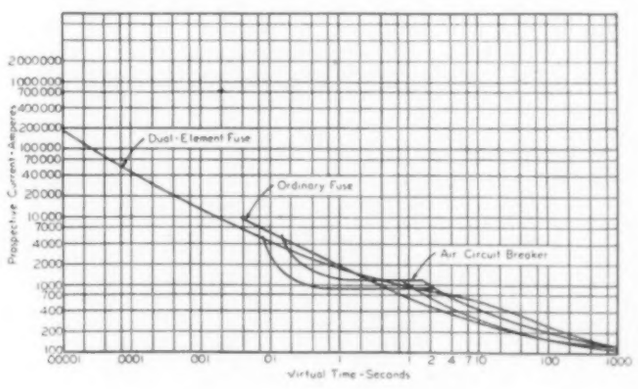


TABLE I

Short-circuit Tests on 250-volt, Dual-element Fuses on 240-v Test Circuit Set to Deliver 165,000 rms Amperes

Rating, amp	Peak current, amp	Clearing time, sec	Peak voltage, volt
30	8,600	0.0005	410
60	10,900	0.0011	390
100	28,000	0.0018	650
200	50,000	0.0020	840
400	87,000	0.0040	1260
600	126,000	0.0052	1280

Testing Laboratories were conducted on 250 and 600 volt dual-element fuses on circuits capable of delivering peak currents as high as 235,000 amperes a-c at rated voltage. The original tests were made on the equivalent of a three-phase, four wire circuit. Such a circuit would have a fuse in each of the three legs with the ground wire solid. A phase-to-phase short-circuit applied on the load side of the fuses would place two fuses in series with the short-circuit. Under such conditions, each and every fuse cleared the maximum current available without igniting readily inflammable material placed around the fuses and with comparatively little noise.

These and similar tests indicated that, with slight modifications, the dual-element fuse could be made to interrupt the maximum current available at rated voltage with only one fuse in series with the short-circuit instead of the two used in the original tests. This change would take care of all possible installations and faults. Three-phase, three-wire systems with one leg grounded, using only two fuses, would be protected. Also phase to ground short circuits on three-phase, four-wire systems, would be less severe than the tests conducted so that this eventuality was anticipated. Also tests proved that the single phase test with only one fuse in series with the short-circuit was more severe than the three-phase short-circuit with all three lines protected, the latter being equivalent to the three-phase circuit-breaker test. Hence the single phase short-circuit test with only one fuse in series with the short-circuit represents the most severe condition that can be realized, and if a dual-element fuse could be made that was capable of interrupting all values of fault currents up to the maximum available, the ideal would be realized.

For this reason the dual-element fuse is being modified to meet these conditions. Tests with only one of the new style 250-volt, dual-element fuse in series with a 240-volt, 60-cycle a-c short-circuit capable of delivering 165,000 rms amperes showed that the 30, 60, 100, 200, 400, and 600 ampere size, on each and every test, cleared the short-circuit without igniting readily inflammable material placed around the fuses and with comparatively little noise. The results are as shown in Table I.

Even though the circuit was set to deliver 165,000 rms amperes, equivalent to 233,000 amperes peak, the fuse operated so rapidly that only 8,600 amperes flowed with the 30-ampere dual-element fuse in the circuit, and even the 600-ampere size limited the current to 126,000 amperes peak or approximately half that available. This limitation of the current is the result of the extremely short clearing times ranging from 0.0005 seconds for the 30-ampere size to 0.0052 seconds for the 600-ampere fuse. The current limitation in turn limits the recovery voltage to a nominal value. Again the voltage shown is the peak value. To convert to rms voltages, the valves must be divided by $\sqrt{2}$ giving a maximum transient voltage of 910 rms volts on the 240-volt circuit. This value certainly is well within normal insulation levels so that danger of insulation flashover during the short-circuit is eliminated.

It might be well to point out that the clearing time is the total time from the instant the switch is closed until the current again returns to zero. It includes the melting and the arcing time. On a 60-cycle circuit the time for one complete cycle under steady state conditions is 0.0167 seconds. Therefore the 30-ampere fuse is clearing the circuit in approximately 1/30 of a cycle, and even the 600-ampere size interrupts the 165,000 amperes available in approximately ¼ cycle. From this it is seen that the mechanics of the circuit interruption is different from that of the circuit-breaker.

In clearing the short-circuit, the circuit-breaker contacts separate and an arc is maintained between the contacts until the current passes through zero. If, at this instant, the contact separation is great enough, the arc is extinguished. If not, the arcing continues for one more half cycle when once again the current passes through zero. The dual-element fuse does not even wait for the first half cycle but actually forces the current to zero thereby limiting it to a nominal value.

Tests also witnessed by the Electrical Testing Laboratories on the 600-volt dual-element fuses on a circuit capable of delivering 212,000 rms amperes at 545 volts, 60 cycles, were equally interesting. Again, with only one fuse in series with the short-circuit, the 30, 60, 100, 200, 400, and 600-ampere new style fuses cleared the fault perfectly. The tabulated results from these tests are shown in Table II.

TABLE II

Short-circuit Tests on 600-volt, Dual-element Fuses on 545-v Test Circuit Set to Deliver 212,000 rms Amperes

Rating, amp	Peak current, amp	Clearing time, sec	Peak voltage, volt
30	14,000	0.0007	770
60	22,000	0.0010	1620
100	35,000	0.0025	1380
200	52,000	0.0047	1380
400	82,000	0.0050	1240
600	146,000	0.0063	1290

The current limiting action of the 600-volt dual-element fuses is equally as great as that of the 250-volt ones. Even though 300,000 peak amperes, equivalent to 212,000 rms amperes, were available, the 30-ampere size limited it to a nominal 14,000 amperes and the 600-ampere fuse held it down to 146,000 amperes. The total clearing time, equal to the melting plus the arcing time, are quite comparable to the times obtained on the 250-volt tests ranging from 0.0007 to 0.0063 seconds on the 30 and 600-ampere fuses respectively. Even

though the short-circuit tests were run at 545 rms volts, equal to 770 volts peak, the transient peak volts were held to a nominal value of 1380 volts or less.

The tabulated data shown in Tables I and II are most interesting and definitely establish the fact that dual-element fuses are capable of interrupting the large fault currents which may develop in large capacity installations such as found in steel mills. However, the data in this form is difficult to use in circuit design, and even is hard to compare with the available data on circuit-breaker interrupting capacity. It is for this reason that the concept of prospective current and virtual time is introduced.

Consider an oscillogram of a typical short-circuit shown in Figure 3. This picture of the 200-ampere, 250-volt dual-element fuse on a 240-volt circuit set to deliver 165,000 rms amperes shows a peak current of 50,000 amperes, a total clearing time of 0.0020 seconds and a peak voltage of 840 volts.

But how can the circuit designer use this data? In the selection of his electrical protection, he first must establish that the devices selected have adequate interrupting capacity and then he must determine if they coordinate properly. To establish the first he calculates the maximum available amperes in his circuit which may be as great as 150,000 amperes. The tests witnessed by the Electrical Testing Laboratories establish the adequacy of the fuses from an interrupting capacity consideration so that these devices may be used for his protection.

Without the concept of prospective current and virtual time, the coordination study at high fault currents becomes extremely cumbersome if not impossible. To illustrate, consider the condition resulting when a 200 and a 400-ampere dual-element fuse are in series with a calculated fault of 100,000 amperes. Assuming that the fault develops at current zero as shown in Figure 4 the current would build up along the sinusoidal curve to some point such as B if only the 200-ampere fuse were in the circuit and to some point D if only the 400-ampere fuse were present. In either case when the dual-element fuse blew, the current would decay along a line such as BC or DE.

Coordination is obtained if the 200-ampere fuse blows to clear the fault before sufficient current flows to melt the 400-ampere fuse. If the instantaneous current flowing is squared, the energy developed while the 200-ampere fuse is blowing is equal to the area under the curve as shown in Figure 4. Since this is less than the amount of energy required to melt the 400-ampere fuse, the fuse is not damaged and proper coordination is obtained.

Rather than force the circuit designer to perform this calculation for every available fault current and combination of fuses, the use of prospective current and virtual time permits the development of time-current characteristics over the entire range based upon available amperes. Since the designer calculates the available amperes from his circuit conditions, the concept greatly simplifies his work. Also it avoids the discussion of what is meant by an rms value of a current lasting only $\frac{1}{30}$ or a cycle. Certainly instantaneous values of peak current must be used at these points because the length of the blow and the current

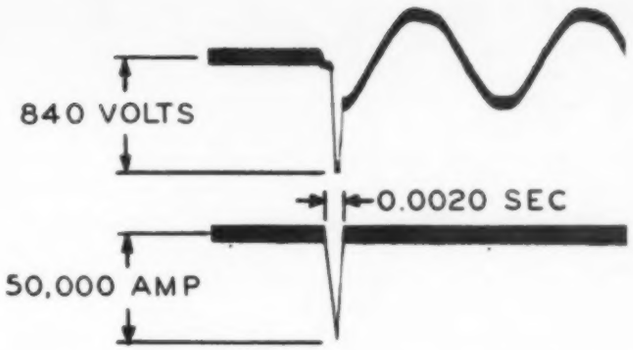


Figure 3 — Oscillogram obtained on 240-volt circuit set to deliver 165,000 rms amperes when protected by a 200-amp, 250-volt dual-element fuse.

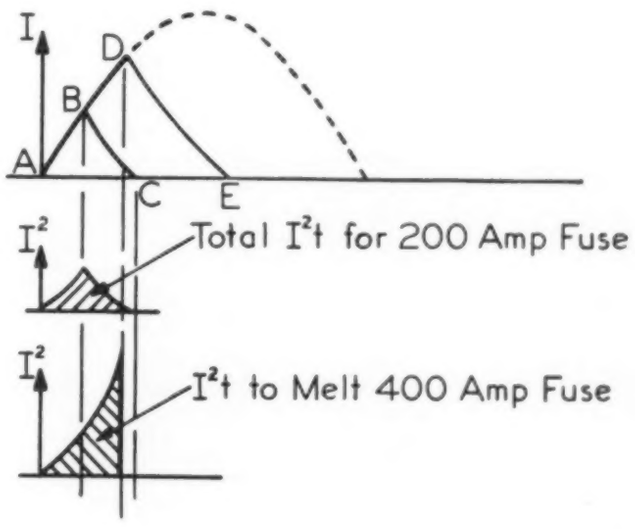
flowing will depend upon the point of closure on the cycle. Hence, root-mean square values become meaningless. But the lower end of the curve is plotted in rms values, and certainly peak values cannot be tacked on the end of rms values.

At times longer than 0.01 seconds on problem develops, but for shorter times it is impossible to draw the time-current characteristic without imposing limitations on it. The prospective current and the virtual time is the simplest limitation, and since it is gaining favor with the International Electrotechnical Commission it would be desirable for the American electrical engineers to seriously consider adopting its use.

The "prospective current" is no different from the "available amperes" now used. In other words, it is the current which would flow if it were not limited by the protective device. It is controlled entirely by the circuit constants.

The "virtual time" is the time that the prospective current must flow to produce the same heating effect in the circuit as that produced by the current flowing while the fuse is blowing. For coordination studies, a virtual melting time and a virtual arcing time must be used. If, at any given prospective current the virtual melting plus arcing time of the smaller fuse is less than

Figure 4 — Coordination between a 200 and a 400-amp fuse when the current flowing is being limited by the smaller fuse.



the virtual melting time of the larger one, proper coordination is obtained.

In other words, the fuse supplier does the greater part of the calculation and supplies the circuit designer with a family of curves from which his coordination data can be obtained. It is for this reason that the time-current characteristic of the dual-element fuse in Figure 2 is carried out to 165,000 amperes, the current available for the tests. The corresponding virtual times were obtained by integrating under the squared current curve calculated from the oscillograms.

For this reason, the dual-element fuse furnishes complete electrical protection. The new style has adequate interrupting capacity to perform safely on even the largest mill circuits. Complete data makes possible time-current characteristics over the entire range of currents from the low, useful overloads up to the largest fault currents available today. Its low temperature of operation provides thermal protection for panelboards and switches, its lower resistance reduces heating in panelboards, its rugged construction provides great vibration and impact strength and its long time-lag assures that it will blow only when there is a case of trouble. Hence, these dual-element fuses have interesting possibilities for the protection of electrical circuits and equipment in steel mills.

DISCUSSION

PRESENTED BY

L. A. TERRY, Superintendent Power and Electric, Gary Works, National Tube Co., Gary, Ind.

R. J. BEESWY, Electrical Superintendent, Inland Steel Co., East Chicago, Ind.

FRANK A. JOHANTGES, Electrical Engineer, International Harvester Co., Wisconsin Steel Works, Chicago, Ill.

B. P. FANTONE, Electrical Engineer, United States Steel Co., Gary Works, Gary, Ind.

J. C. LEBENS, Chief Engineer, Bussman Manufacturing Co., St. Louis, Mo.

L. A. Terry: My remarks will be as that of a user of the dual-element fuse. Their use for the protection of electrical equipment is a great improvement over the ordinary fuse. Many cases can be sighted where dual-element fuses have saved equipment from damage. This is especially true on equipment which is not controlled by starters with built-in thermal devices, such as transformers, solenoids, control circuits, etc. They are an advantage in motor circuits in that they back up thermal protected starters and provide current limit and fast blowing in case of a short circuit.

Such cartridge fuses can and may be used in circuit-protected sizes the same as you use ordinary types of fuses in accordance with the National Electrical Code. Their use does require more training of motor inspectors in their proper application and, no doubt, you will have to see that the stores department carries the various sizes required in a plant. If motor running protection sizes are used, and are not immediately available, then the largest size the switch may hold would still give adequate protection temporarily the same as ordinary fuses.

R. J. Beeswy: We have become accustomed to associating charts, curves and oscillograms with electronics, rotating regulators, amplifiers, etc. Never did we think it would happen to our old reliable protective device, the fuse. Recognizing the importance of matching the time current characteristics of the protective device and the electrical equipment, I would like to know what is done to match radiating characteristics so that a motor, subject to frequently recurring overloads, will be protected if its cooling time is longer than that of the fuse.

Is it necessary to consider frequency, voltage, available short circuit current, motor horsepower and type of motor winding, whether class A or B, for each fuse application?

I would be interested to know how the short circuit current was limited to 14,000 amps by a 30-amp fuse on a bus with available short circuit current of 300,000 amps. What arc quenching medium is used in the fuse?

For a remote controlled installation where a contactor is a necessity and overload protection can be easily applied, what advantage would be gained by the use of these fuses?

As the dual-element fuses fit in the same clips that will take a standard one-time or renewable fuse, provided for control or light circuits and where thermal overload protection is not necessary, I have reason to believe there would be errors and confusion in the correct replacement of these fuses.

Dirty and loose clips were the cause of most of our fuse troubles, this and the taking of fuses from one circuit for use in another by an unauthorized person has been stopped by standardizing on visetype fuse clips.

F. A. Johantges: We have heard from the users and non-users of these fuses. We use them to protect some of our alternating current motors and they have proven satisfactory. We do find it necessary to be certain that the maintenance man understands this fuse and that he does not replace it with one of incorrect size.

Mr. Lebens has outlined a new thought on the use of the fuse. We usually think of the circuit breaker opening the circuit in case of trouble, but apparently this new fuse will open before the circuit breaker can act and, in so doing, must not be destroyed or cause a fire.

I wish to ask if Mr. Lebens proposes to replace the circuit breaker with dual-element fuses within the limits of their size? This would be a change from our present practice of using the fuse as secondary to the circuit breaker. This paper has discussed the use of the fuse for alternating current circuits. Could they be used equally as well on direct current circuits?

If we are to use both the circuit breaker and dual-element fuse in our power circuits, then we must be careful in the selection of the devices in order not to duplicate on the protection desired.

B. P. Fantone: I have two questions. In the tests you mentioned for obtaining the high interrupting capacities, were your fuses installed in specially built or com-

mercialy available standard type switches? Second, does the concept of virtual time and prospective current apply to circuit breakers in the same manner as it does to switches?

John C. Lebens: I am glad that you all agree that the lowly fuse has made good. That, to us, is quite a compliment. We feel that the dual-element fuse is more than a fuse, it actually is a protective device in the true sense of the word.

As pointed out by Mr. Terry, electrical engineers are divided into two distinct groups. The first consists of the users of dual-element fuses who are enthusiastic boosters for the protection afforded by them and the second are the non-users who cannot quite believe that the devices can do everything claimed for them.

The second group is exemplified by Mr. Beeswy who has trouble associating charts, curves, and oscillograms with the old reliable protective device, the fuse. With reference to the specific questions raised by Mr. Beeswy we have found that it is relatively simple to match the characteristic of the fuse to that of the motor, subject to frequent recurring overloads. Even though the thermal capacity of the motor is greater than that of the fuse, the effect of repeated heating and cooling on the two devices is substantially the same.

If the size of the dual-element fuse is selected properly for the first cycle, its rate of cooling will match the rate of heating in exactly the same manner as the rate of cooling of the motor will match its heating rate. Hence, repeated cycling of the two devices will produce the same effect on both so that adequate protection without useless blows is assured.

The application of the dual-element fuse to the protection of a motor is quite simple because the motor is damaged and the fuse blows in exactly the same manner. Both devices are affected by the heat generated by the current flowing through them.

Tests conducted on the dual-element fuses from direct current up to 400 cycles indicate that the device is relatively insensitive to frequency changes. In fact, it was impossible to detect any effect of frequency in the tests conducted. Voltage has no effect on the time-current characteristic of the fuse, but does establish the physical dimensions so that the device can interrupt the circuit voltage without damage. Tests conducted show that the fuse will perform satisfactorily under the largest short-circuit currents available today. Hence, the short-circuit currents need not influence the selection of the proper fuse for motor protection.

Since the motor horsepower and the type of motor winding affects the current flowing through the motor, the influence of these factors automatically is considered when the fuse size is selected with reference to the full load current of the motor. In like manner, the type of insulation affects the full load current of the motor in that more current can flow if the higher temperature insulation is selected. Again this is reflected in the size of the fuse selected with reference to the motor current.

The short-circuit current was limited to 14,000 amperes peak by a 30-ampere fuse on a bus with the available short-circuit current greatly in excess of this value because of the current-limiting action of the device. As pointed out in the paper, the time from the instant the switch is closed until the current again returns to zero is only a fraction of a cycle. Hence, no matter at what instant the switch is closed, the current does not have an opportunity to build up to the full available amperes before the fuse operates to clear the short-circuit. For this reason, the current is held to a nominal value of 14,000 amperes peak for a 30-ampere fuse even though the available ampere is greatly in excess of this figure.

These fuses can furnish short-circuit and back-up protection for remote controlled installations where a contactor is a necessity and overload protection can be easily applied. The thermal elements in the overload relays will explode under heavy short-circuit conditions unless furnished with short-circuit protection. Ordinary fuses can be used for this purpose, but with the dual-element fuse high interrupting capacity is assured in addition to overload protection designed to operate if the thermal overload relay sticks or fails to function.

The worry concerning the replacement of the blown fuse with one of the proper rating is understandable because little educational effort has been made to assure proper replacement of the ordinary fuse. This is the direct result of the fact that the exact size of the ordinary fuse was not too important. However, selecting the proper size dual element fuse is no more difficult than selecting the proper size heater for the overload relay. In fact, these fuses are clearly marked with ampere rating whereas the overload heater is marked with a serial number making it difficult to identify.

We have found that proper fuse replacement can be obtained if the electrician is educated to appreciate the importance of the proper size.

We also are glad to hear that Mr. Johantges has obtained adequate protection with these fuses. Even more so we are glad to realize that his maintenance men understand the performance of the fuse thereby obtaining correct replacement.

With reference to the specific question of whether we propose to replace the circuit-breaker with such fuses, we feel the trend in circuit capacity is rapidly approaching the point where such a step will be given serious consideration. Until quite recently, the possibility of obtaining short-circuit currents in excess of 25,000 amperes was extremely remote, because the circuit capacity would not permit such currents to flow. However, today such currents are not at all unusual.

A circuit-breaker of the proper rating will perform satisfactorily under these heavy short-circuit currents but the current will flow for one, two, or even three cycles without any current limitation. This means that the circuit as well as the associated equipment must be capable of withstanding the heavy short-circuit current until it is interrupted by the circuit-breaker. In many cases this is an impossibility.

For this reason the current-limiting feature of the fuse is steadily becoming more important and, in our opinion, a situation may develop in the future where this one feature will justify the use of the fuse for protection against heavy fault currents.

The performance of the fuse on direct current circuits is substantially the same as that obtained for alternating current circuits. In most cases the circuit

designer is more interested in the a-c performance and it was for this reason that the a-c short-circuit results were described.

In answer to Mr. Fantone's questions, interrupting capacity tests were conducted on these fuses mounted in standard three-pole safety switches commercially available. Switches of two different manufacturers were tested. One was selected as being representative of the poorest construction from a short-circuit consideration, and the other as representative of the best construction. In both cases the fuses cleared the short-circuit without damaging the switches. After the short-circuit test, the switch mechanism was in operating condition and heat runs on the switches indicated that the contacts had not been damaged. These tests show that the current-limiting action of the fuses protected the switches from the heavy short-circuit currents available.

As pointed out in the paper, the concept of virtual time and prospective current is extremely valuable in analyzing the performance of the fuse. It is necessary because the current flows for only a fraction of the cycle and the peak value of current flowing is dependent upon the point of closure on the current wave. The duration of the short-circuit also varies so that the total energy passed by the fuse during the short-circuit is the same.

The concept is not so important in the study of the circuit-breaker performance because the current flows for at least one cycle before the circuit-breaker opens to clear the circuit. Under these conditions, the short-circuit current can be converted to a root mean square current by means of an asymmetry factor. However, the concept of virtual time and prospective current can be used with the circuit-breaker although it is not necessary.

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THE RENDLEMAN ROD MILL

By NORMAN RENDLEMAN
Special Consultant
and
A. WILSON
Assistant Chief Roll Designer
United Engineering and Foundry Co.
Pittsburgh, Pa.

. . . . the production of this rod mill is almost equivalent to three single strand mills . . . .

▲ THE continuous type of rod mill had its inception at or about the turn of the century, to meet the demand for lower operating costs and heavier bundles in the wire mills. The product of these mills is classed as semi-finished material and originally went into nails, staples, farm wire, and other common products. The demand on the rod mill today for much of its product is for cold forging steel, valve spring wire, cable wire, mechanical wire, etc., all of which require the highest surface quality.

Tolerance for size, seams and pitting are among the principal causes for rejection and are all chargeable to the mill. It is noteworthy that the older mills are competing rather favorably with the more modern rod mills in the quality field. However, most existing rod mills are not producing the quality demanded by present day users of wire.

In design and operation, the rod mill is the most complex of all the hot rolling mills. It does more rolling per ton of steel than any other. For example, a 2½ in. x 2½ in. x 30 ft billet is elongated to 5000 feet of 0.218 in. rod, resulting in 629 pounds of product, and 15,900 feet are required for one ton. A production of 50 tons per hour for 24 hours would total 19,008,000 feet or 3600 miles of 0.218 in. rod. The necessity for speed and continuous operation of these mills is therefore apparent.

This rod mill is essentially a 3-strand mill with three lines employed to roll 400, 500 or 600 lb billets into any size of rod. In operation, the mill approaches the equivalent of three single strand mills. In this mill the fundamental components of a rod mill are organized in a new and highly advantageous way.

The mill as illustrated (Figure 1) consists of twenty-two stands of rolls arranged in three divisions, with eight stands in the roughing train, eight stands in the intermediate train, and six stands in the finishing train.

BUNDLE BUSTER

To insure proper feeding of billets into the furnace at the required rate of speed and to eliminate all unnecessary manual separating of billet bundles, our company has designed and built the bundle buster (Figure 2).

The billets are placed on a table with a chain transfer which moves the billets up to a series of three sets of wheels traveling at a very slow rate of speed and by means of their speed ratios, the billets are selected one by one from the bundle. These wheels roll the billets down to a walking beam table which walks the billets up to take off arms. These arms deposit the billets one at a time on a run-in table where they enter the furnace. The run-in table has kick-off arms to reject any unsuitable billets.

ROUGHING TRAIN

The roughing train consists of eight stands of rolls equipped with roller bearings. Stands No. 1 and 2 are 16 in. mills driven by a single d-c motor and serve to equalize the areas of 2–2¼–2½ in. billets at stand No. 3 in the ratio of speed × area = constant.

Stands No. 3 to No. 8 are 15 in. mills preferably driven by a single motor, as illustrated (Figure 1).

The gear ratios in the drives are designed to permit the moving of stands No. 4 and 6 to the No. 8 stand position when rolling a particular range of large rod sizes.

No excessive pass reductions are employed and entering problems are averted. This is conducive to smooth operation of the mill, longer roll life and better surface quality of product. It is never necessary to adjust the rolls when rolling the larger rod sizes as is the

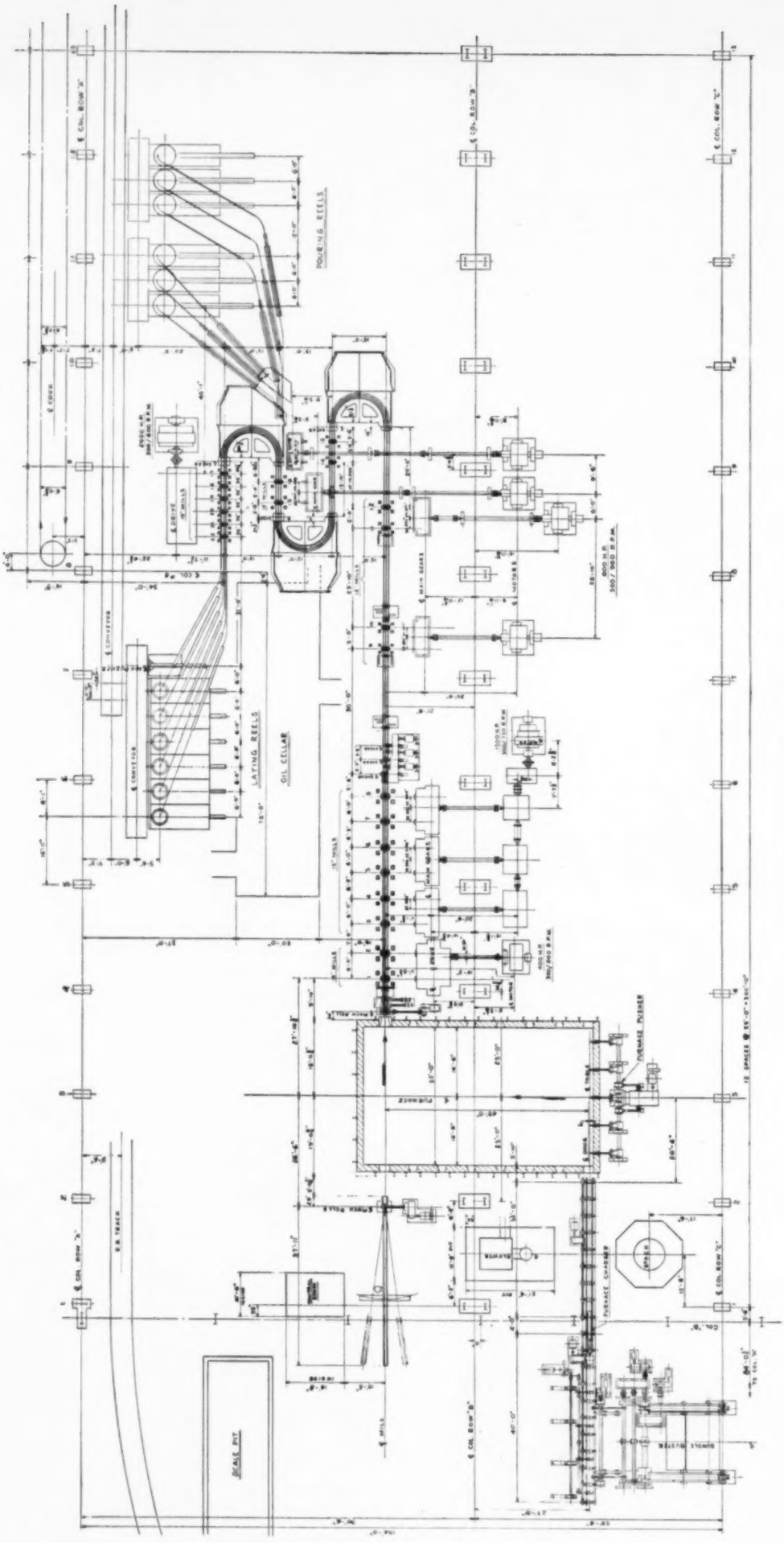


Figure 1 — General plan and layout of Rendleman rod mill.

practice on present day rod mills which leads to much additional guide equipment and the inevitable seams, to say nothing of the down time to make these changes.

Since definite steel lines are maintained, the roll stands move in a horizontal plane to bring the roll passes into the line of steel travel as the grooves wear (Figure 3). This feature makes it unnecessary for the operator to use prematurely worn out grooves rather than stop operations of the mill for a roll change. In other words, the grooves in any particular stand of rolls are all worn out before any roll changing is done.

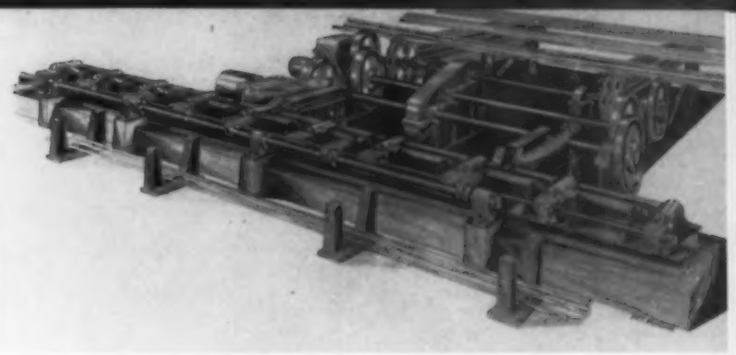


Figure 2 — The bundle buster eliminates unnecessary manual separation of the billet bundles.

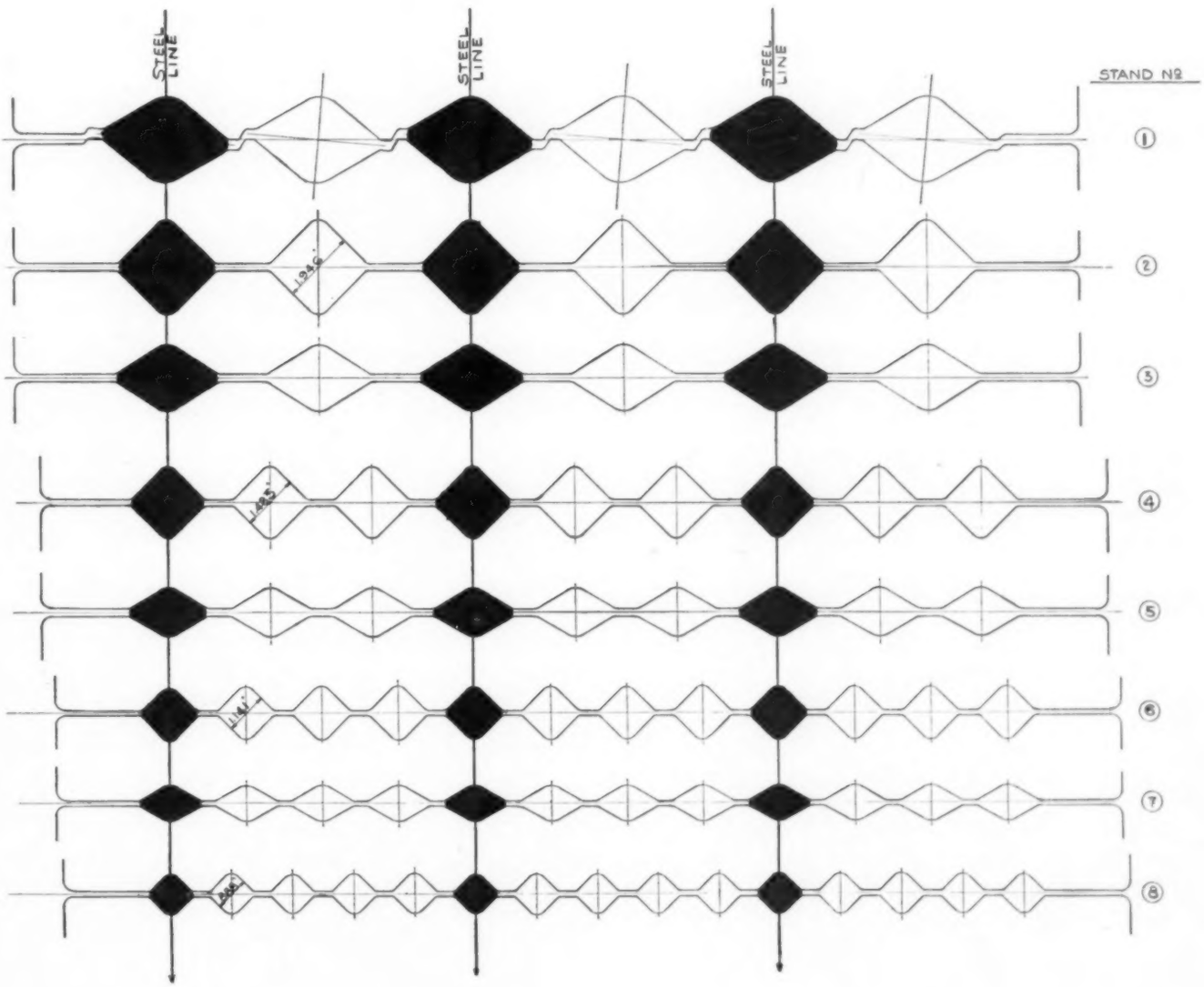
INTERMEDIATE TRAIN

The intermediate train consists of eight stands of rolls equipped with roller and ball thrust bearings and arranged in pairs or as duo sets. Each pair is driven by a d-c motor.

These eight stands are arranged in such a manner as to allow four or five controlled loops where stock may be accumulated at a controlled rate to insure a taperless bar entering the six-stand finishing train when rolling 0.218 in. to $\frac{3}{8}$ in. rods. As you will see on the flow diagram, various stands are removed when rolling large rods, thus making it possible to roll bar mill tolerances. Rods $\frac{3}{8}$ to $\frac{13}{32}$ in. diameter are finished in the last two stands of the intermediate train. All larger bars are finished from set 15 by repeating the lead ovals from set 13.

Another great advantage of this arrangement is, it eliminates the repeating of small ovals so prevalent on

Figure 3 — The design of the roughing mill rolls is such that it minimizes mill shut downs due to roll wear.



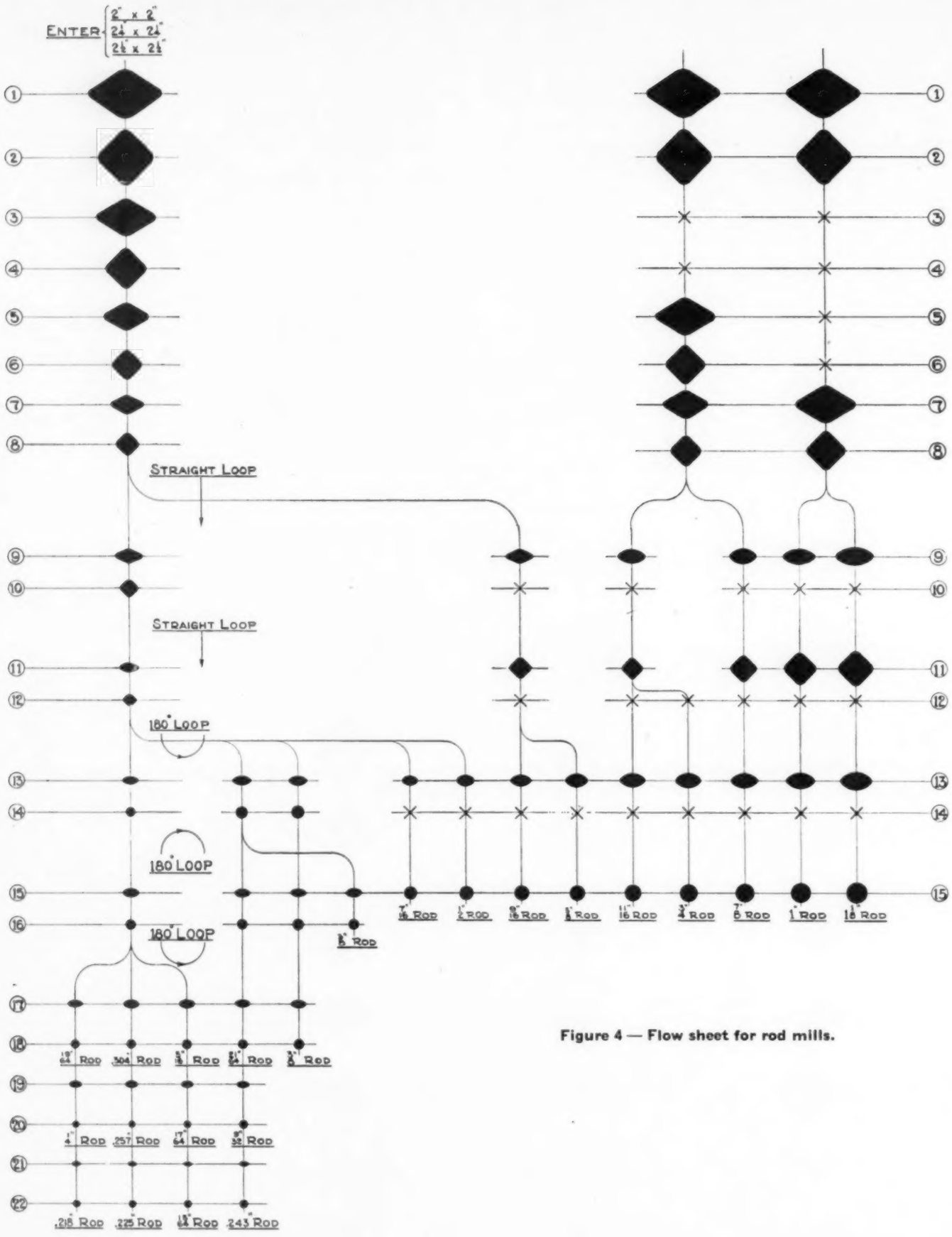


Figure 4 — Flow sheet for rod mills.

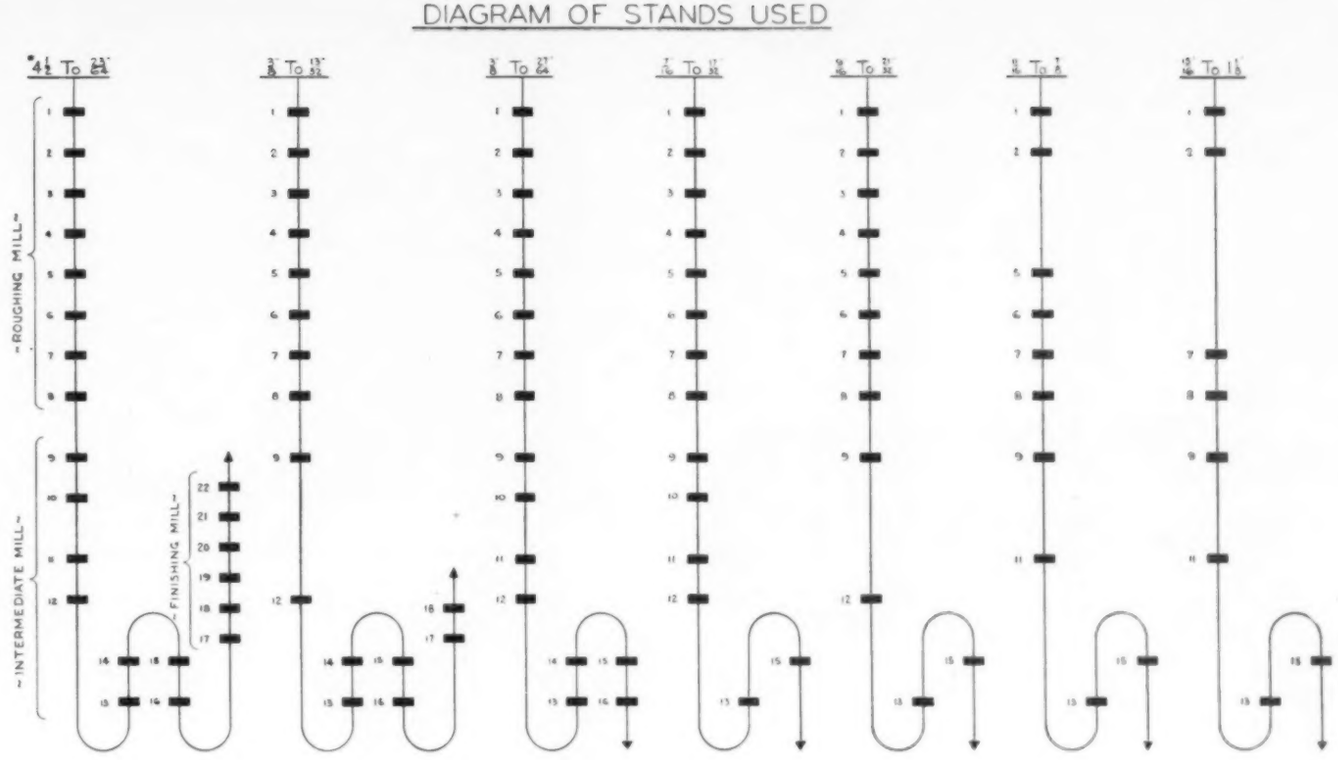


Figure 5 — Layout of stands for rolling various rod sizes.

some present day rod mills. The repeating of small ovals has always been a source of trouble especially at a high rate of speed. The first oval to be repeated on the rod mill is the oval for a $^{7}/_{16}$ in. diam rod and this at a slow rate of speed. The stiffness of this oval is such to allow ease of entering the tight guides required when rolling to bar tolerances.

SIX STAND FINISHING TRAIN

The six-stand finishing train, equipped with roller and ball thrust bearings is driven by a single d-c motor. When rolling 0.218 in. rod (three strands) at the rate of 50 tons per hour, the finishing or stand No. 22 will have a speed of 4750 fpm. The three strands are piped to six laying reels and then to proper conveyors for further processing.

The method of securing larged rod sizes from the six stand mill is shown on the flow diagram where it is more readily understood.

Subject to mechanical limitations as to speed, the rate of production is always equal to the capacity of the furnace. To illustrate, let us assume a fixed rate of fifty tons per hour from the furnace, and an average billet weight of 600 pounds, 167 billets per hour are required from the furnace, or one each twenty-two seconds.

To insure the reception of these billets into and through the mill, the mill speed is adjusted for, say, one hundred eighty billets per hour, or one each twenty seconds. The mill is, therefore, faster than the furnace and will readily accept one hundred sixty-seven billets per hour.

The one thing that must be kept in mind about the mill is that although essentialy a three strand mill, it is never necessary to roll a definite number of strands as it is always possible to roll any fractional number below 3 strands. The three lines are employed to roll all sizes. It is merely a matter of feeding the bars into the mill and the speed at which the mill takes it away. It will always roll at any capacity of the furnace.

FLOW DIAGRAM

Figures 4 and 5 show the flow diagram and positioning of stands for rolling 0.218 to $1^{1}/_{8}$ in. rod inclusive. Either 2 in.– 2–$^{1}/_{4}$ in. or 2–$^{1}/_{2}$ in. billets are entered into the mill depending on the size coil desired whether 400, 500 or 600 lb.

When rolling the 2 in. billet, No. 1 stand is idle and No. 2 stand is used as a pinch roll. When rolling 2–$^{1}/_{4}$ in. billets, the speed of these two stands are increased to compensate for the difference in area. All these billets are rolled to 0.888 in. sq out of No. 8 stand regardless of the rod size rolled between 0.218 in. and $^{43}/_{64}$ in. In other words, once the roughing mill is set it need never be adjusted for various sizes of squares to make various sizes of rod.

Rod sizes up to and including $^{11}/_{32}$ in. are rolled with no roll changing in the first fourteen stands. The only changing necessary are the lead oval and finishing round rolls in No. 15 and No. 16 to roll $^{3}/_{8}$ in. rod.

For sizes $^{7}/_{16}$ in. and $^{1}/_{2}$ in., stands No. 14 and No. 16 are removed and the lead oval and finishing round rolls

are placed in the No. 13 and No. 15 positions. The square out of No. 12 regularly used for the small rod line is in position to make these sizes.

To make 9/16 to 5/8 in., the square in No. 10 stand regularly used for small rod is moved, stand and guides, to the position of No. 11 stand. This is the lead square for the above sizes.

To make 11/16 to 7/8 in. rod it is necessary to obtain more stock from the roughing train. This is accomplished by removing stands Nos. 7 and 8 and moving stands Nos. 3, 4, 5 and 6 to the positions of stands Nos. 5, 6, 7 and 8. Also when rolling 1 in. to 1-1/8 in. rod stands No. 5, 6, 7, and 8 are removed and stands No. 3 and 4 are moved to the position of stands No. 7 and 8.

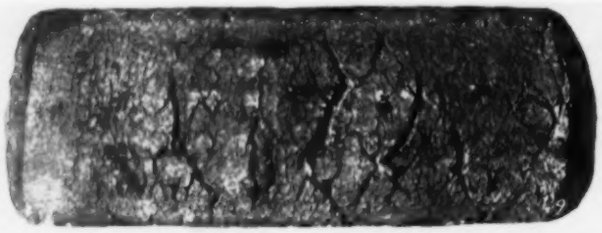


Figure 6 — Illustration shows an 8 x 8-in. bloom with excessive seams.

This moving operation is done with a minimum of down time since stands and guides are moved as one unit.

The reason for placing these stands always in the No. 7 and 8 position is to obtain the necessary speed out of the roughing train to maintain proper production.

Figures 6, 7, 8 and 9 show the results of the diamond and square rolling to eliminate seams.

An 8 x 8 in. bloom that had excessive seams (Figure 6) was selected. This bloom ordinarily would have been sent back for remelting, but due to its bad condition, was rolled to give the diamond and square method a severe test. The 8 x 8 in. was rolled to a 6 x 6 in. (Figure 7) then to a 4 x 4 in. (Figure 8) and on down to a 1-3/4 in. sq billet (Figure 9).

At each of the above mentioned square sizes, a sample was taken from the top end of the top bloom from the ingot and upset 30 per cent to open the seams. Notice the seams are still prevalent in the 6 x 6 in. but as the ingot is rolled on down to the smaller sizes, the seams become less prevalent, and at the 1-3/4 in. billet they have disappeared entirely. Figures 6-9 were made after the upsetting operation.

Figure 7 — Bloom shown in Figure 6 has been rolled to a 6 x 6 in. in this illustration.

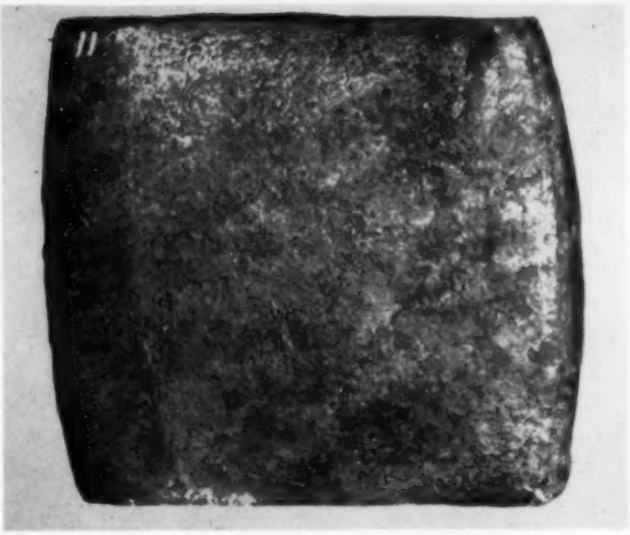


Figure 8 — Next step in the rolling of the bloom to a 4 x 4 in. is here shown.

It must be understood that simply because diamond and square rolling is instituted in a rod mill such as the present day rod mills with heavy reductions, is no insurance seamless rod will be rolled. There must be a combination of diamonds and squares with light reductions.

On this rod mill, roughing train roll passes are designed with diamonds and squares with light reductions and seamless rods are the result.

Figure 9 — The final 3/4 x 1 3/4 in. billet shows no signs of the seams.

Summarizing all the preceding, the improvements incorporated in this rod mill design have been made with the idea in mind of obtaining the following objectives:

1. To produce rods without seams.
2. To roll all rod sizes to closer tolerances.
3. To roll sizes $\frac{7}{16}$ in. and upward to bar mill specifications.
4. To roll the complete range of rod sizes with a minimum of lost time for mill changes.
5. To increase production on all sizes $\frac{1}{4}$ in. and upward to meet any predetermined furnace capacity.
6. The application of 400, 500 or 600 lb billets for any size rod without serious delay to the mill.

DISCUSSION

PRESENTED BY

MARTIN L. WEIKERT, Assistant Superintendent Rail and Roll Dept., Bethlehem Steel Co., Sparrows Point, Md.

WILLIAM HERMAN, Superintendent Rolling Mills, Keystone Steel & Wire Co., Peoria, Ill.

A. WILSON, Assistant Chief Roll Designer, United Engineering and Foundry Co., Pittsburgh, Pa.

C. W. BARRETT, Assistant District Manager, Republic Steel Corp., Buffalo, N. Y.

ROBERT S. FINK, Assistant Superintendent, Crucible Steel Co. of America, Park Works, Pittsburgh, Pa.

HAZEN J. LEAVER, Project Engineer, Jones & Laughlin Steel Corp., Pittsburgh, Pa. now Assistant to President, Treadwell Engineering Corp., Easton, Pa.

Martin L. Weikert: The description of this mill is very interesting. Certain sized sections are taken out of the roughing mill each to accommodate a range of sizes of finished bar and all sizes can be rolled with no adjustment of the roughing mill rolls. Our Lebanon plant bar mill is operated in this manner. Roll passes for the No. 2 rod and bar mill at Sparrows Point were designed likewise. However, we found that by maintaining a certain size out of the roughing mill, ovals for the smallest product of that range were long and thin, and for the largest size of the same range were short and stubby. We prefer having an oval of a shape which can be easily controlled and handled and adjust the roughing mill rolls for this purpose.

It is also noted that when a bar is wanted out of No. 6 stand, stands No. 7 and 8 are removed and stands No. 3, 4, 5 and 6 are moved up to the 5, 6, 7 and 8 positions. Also when a bar is wanted out of No. 4, stands No. 5 and 6 are taken out and stands No. 3 and 4 moved up to the No. 7 and 8 position. On No. 2 rod and bar mill at Sparrows Point when No. 7 and 8 are not in use they are removed and dummy fabricated tables with troughs are set in their place. Additional tables are used when stands No. 5 and 6 are removed, and a bar is taken out of No. 4 stand. This is less time consuming. Also, the speeds in our gear drive do not permit operating No. 4 stand in the No. 8 position.

William Herman: What kind of spreaders do you use in the finishing mill to hold the rolls apart?

A. Wilson: We have hydraulic separators in the housing, between chocks for roll separation.

Charles W. Barrett: I have wondered what tolerances we might expect from triple stranding bar products in two continuous stands, and what facilities have you made available for descaling in using your diamond and square pass layout in the roughing line? I would also like to know if you do not expect to experience a short portion of the front end of the billet not turning up properly in the first pass, without the use of a mechanical turn-up device.

A. Wilson: On the bar mill tolerances on duo sets, we are up to $\frac{3}{8}$–$\frac{27}{64}$ in. and we feel we are still in the rod tolerance. When we drop off the fourteen and fifteen stands and go to $\frac{1}{2}$ in. we are in the bar tolerance, so we have an open mill for the last two stands and we have a great chance of getting a good tolerance on that size rod. On the smaller rods up to $\frac{27}{64}$ in. in the duo stands, if the rolls are not turned just properly, it is quite possible that you will not be in bar mill tolerance, but certainly in rod mill tolerance.

On the second question, I do not think we have any provision for descaling on the mill.

The third question of turning the bar up, as I said before, has been tried and tested. I have seen it many times and I have never noticed any bad front end on the billets.

Robert S. Fink: Can you convert that mill to roll various sections, hexagons, octagons, squares, such as rod mills are producing?

A. Wilson: It is quite possible to convert that mill to roll hexagons and that sort of section within bar mill tolerance.

William Herman: I would like to know how much production of 0.218 in. rod you expect from this mill?

A. Wilson: Fifty tons an hour.

Hazen Leaver: The layout as illustrated is not the layout for the Jones & Laughlin mill, although the pass layout, as shown, is identical. The difference is that the stands for the J & L mill are paired and driven by one motor for each two stands throughout the roughing and intermediate stands. The finishing mill is driven as shown in Figure 1.

The motors themselves might be interesting to those who are designing mills. These motors have a three to one speed range, but have Ward-Leonard control. The motors are of such size that we can keep well within the speed cone for the mill by taking reduced voltage on the lower speeds of the mill. It gives us great flexibility in moving the stands wherever we see fit to put them and still have the mill under complete control.

A. Wilson: With reference to Mr. Leaver's comments, the layout given in Figure 1 is not the Jones & Laughlin mill as Mr. Leaver apparently assumes. The mill shown is located at a plant in the Chicago district. This mill has one motor on the last 6 stands of the roughing train and this we prefer because it is more economical. When you have one motor to 2-stands, an error in roll turning can be compensated by speeding up or slowing down. However, we feel that if the rolls are turned properly and the mill is set to the particular product being rolled, there should never be any necessity to change speed and diameter, and for this reason we feel the single motor is preferable. However, this is a matter of opinion and local circumstances or conditions may make one method preferable over the other.

ANNEALING FOR NARROW STRIP MILLS

By J. L. WHITTEN
Vice President
Lee Wilson Engineering Co., Inc.
Cleveland, Ohio

. . . . although narrow strip mill products may require different handling from the large mills, the old problem of making efficiency offset higher costs is still present . . . . developments in narrow strip mill annealing units have provided some of the answers to the efficiency question . . . .

▲ IT is the purpose of this paper to show how extensively the narrow strip industry has adopted the most modern conception of annealing design in single-stack furnaces with high convection gas circulating systems, high heat inputs, alloy inner covers, and oil sealed bases to eliminate the use of sand for seals with all the attendant objections to this sealing medium for mills which must produce steel of exceptional finish and close tolerance for gauges.

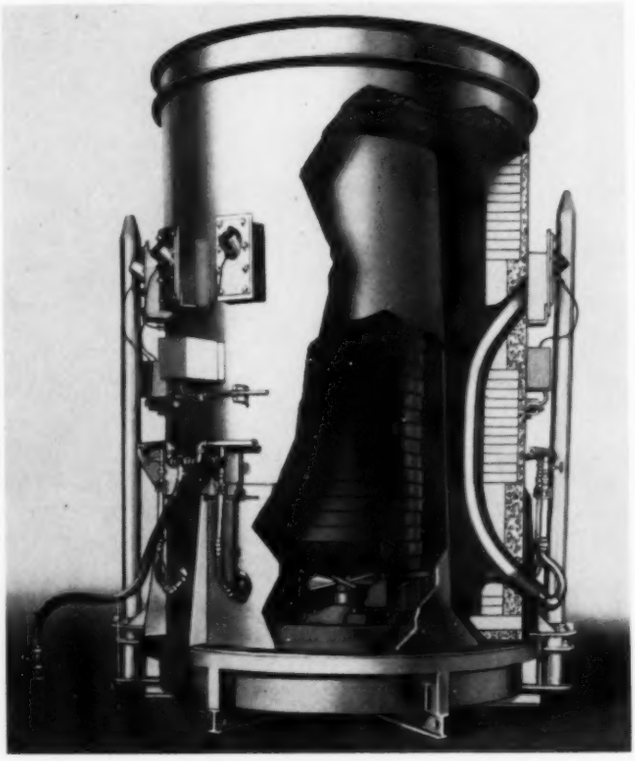
If the large strip mills have taken great technological strides in equipment design, the mills rolling narrower material for all carbon ranges are not behind their larger associates in the type of equipment used. In fact, as far as annealing is concerned, they have adopted the entire principle of radiant plus convection heat, and have put it to use to achieve tons per hour and annealing cost per ton figures that the larger mills have not reached for equivalent physical properties, and uniformity of temperature saturation in the coils.

Perhaps this seizure on the ultimate in equipment design is natural, as the multitudinous requirements of the narrow strip mill, with limited tonnages per order, put a premium on exact processing methods, and of course, the small mill is just as interested in high quality at low cost as the large mills.

Perhaps at this time a definition should be made of the narrow strip mill. The general conception of this "narrow strip mill" is one where the mill size is 30 in. or less, and the products rolled are 20 to 24 in. maximum. This size is again probably slit to narrower widths for finished delivery, down to one in. wide bands or even smaller. The economies of operation and annealing will be to roll as wide as possible, anneal, temper roll and slit to width, and to anneal in as large diameter coils as possible.

To cast a glimpse backward in this industry, up to five years ago, coil sizes were in general limited to approximately 5000 lb maximum weight, with the resulting coil diam as large as could be heated by radiation, principally with some slight help from gas circulation from a 1½-hp fan. Coils were mainly 34-38-in. outside diam and piling heights were 72-90-in., with charges of around ten tons. The furnace design was as shown in Figure 1, consisting of a bank of vertical radiant

Figure 1 — Illustration shows original type of radiant tube-heated bell furnace.



tubes equally spaced around the periphery with a fuel input of 800,000 to 1,000,000 Btu per hr maximum. Products of acceptable uniformity and Rockwell test could be produced at approximately 1000 lb per hr for low carbon steel or at the most of around 1250 lb per hr if the charge were maintained at or near the maximum possible weight.

Some mills were still using "in and out" furnaces with charges of 20 tons at this time, and some of the larger mills annealed their narrow strip in random groupings on sheet furnace bases.

In 1946, the first installation was made of the high speed convection furnace with greatly elevated fuel inputs. The results justified the immediate acceptance of the radiant convector heating principle, as shown in Figure 2. The flow of gases was directed through a baffle to promote velocities up to 6000 fpm and effect a tremendous convection transfer of heat to the gases. These in turn were passed through separators or convector plates, placed between every coil, or every 20-24 in. in the charge for narrower coils, in order to heat the coils from the edges and not through the laminations.

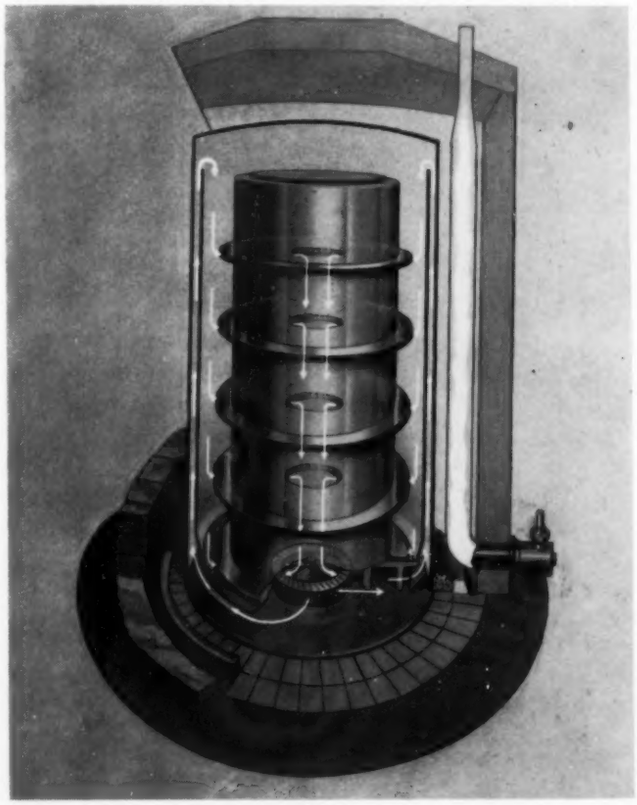


Figure 2 — The principle of the radiant convector furnace is shown in this sketch. Arrows indicate flow.

To achieve the velocities required and to move sufficient gas to provide the heat transfer, the recirculating fan was driven by a 15-hp motor.

This system of heating no longer placed a limitation on coil diameter, so larger hot mill coils could be processed or else two or even three coils could be wrapped together after cold rolling to make large diameter coils. The piling height could now be increased as the circulating system could carry the heat when it was needed; so the new furnace sizes were built for 48-in.

Figure 3 — Plant illustrated double wraps some coils as can be seen in the foreground.

outside diam coils and larger (now up to 66 in.) and for piling heights of first 96 in., then 120 in. and now to 150 in. The fuel input had to be increased accordingly and now range from 2,500,000 to 3,500,000 Btu per hr, charge weights from 16 to 36 tons and production yield for low carbon steels from 1¼ to 2 tons per furnace hour, with still greater yields in prospect from installations now being made which will operate with 60-ton charges.

Mention should be made of the use of this annealing system in high carbon steel mills. The radiant convection system has stepped yields up from 400 lb per hr in the small diameter furnace to 1000 lb per hr for full spheroidization in 48-in. diam furnaces with not over 3 points of Rockwell variation throughout the charge. Figure 3 shows such an installation which processes narrow coils, double and triple wrapped to get large diameter coils. In the narrow widths, the coils are usually spun out to large diameters rather than recoiled.

Here, it might be well to discuss rates of heating from actual cycles. Figure 4 is a complete cycle of a charge of five 22½-in. wide coil, 20-in. inside diam x 47½-in. outside diam, weighing 22½ tons. While the first cycles were run with a thermocouple at the top outside edge of the charge and one at the bottom touching the bottom convector plate, experience has enabled low carbon charges to be run with only the bottom thermocouple for control. Heat penetration was studied with thermocouples put in place in the coil on the windup reel of the cold mill, so now the cycles are complete when the bottom thermocouple reaches 1250 F for most charges. This can be seen as taking twelve hours. The rate of temperature advance across the coil is of such uniformity that very little so-called soak is necessary.

Cooling is almost as fast as heating, and is accelerated by means of air blowing and water quenching with a forced cooler (Figure 5). Just as soon as the hot furnace is removed from the inner cover, this forced cooler is dropped into place and plugged in for power to start the cooling fan. A large volume of air is moved at fairly high velocities over the hot inner cover surface

and when the temperature within the charge has been considerably lowered, the water spray can be turned on to further hasten the cooling. Cooling times have been shortened again with an increase in fan volume and horsepower. The curve shows the cooling time at 14½ hr for a total cycle of 26½ hr from start to end.

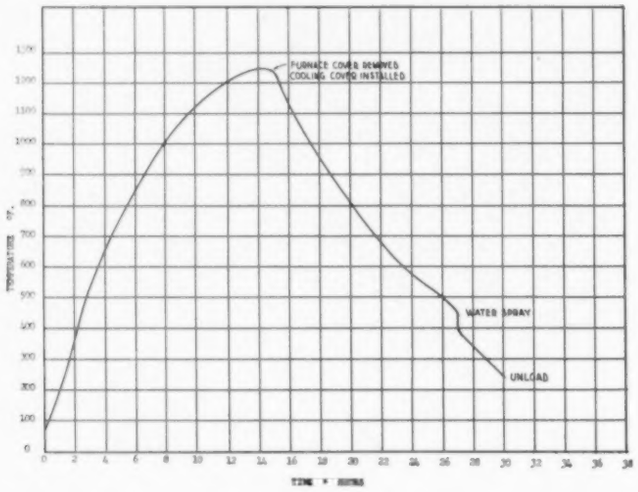


Figure 4 — Curve shows typical cycle for a radiant convector furnace for narrow strip coils. Charge consists of four 22½-in. wide coils.

Steel annealed in these cycles has met every requirement of deep drawing without long soaks. The Rockwell readings for steel of normal analysis are usually 3 points higher than has been usual, but on account of faster heating and cooling, the grain size is smaller and much more uniform than is usual on longer cycles, which makes for better drawing qualities. However, it should be pointed out that neither this annealing system, nor any other can overcome the effects of ingot segregation of the alloying elements of steel. Present operating practice, under pressure of production demands, have gradually increased the percentage of cropping to the point where the effects of this show up in the coils rolled from the upper end of most ingots.

Just for the help of the cold mill operators and metallurgists, in Figure 6 is shown the segregation of carbon, sulphur, and phosphorous in a quarter section of a rimmed ingot. With average cropping decreased from 30 to 15 per cent, a segregated area is almost sure to be included in one or more of the slabs rolled from the ingot. If the carbon in the resulting coil is up to 0.18 per cent in some parts, and the other elements correspondingly increased, the annealing process will never soften the steel to match the results of the part of the coil of normal analysis. Here is the answer, not underannealing, if tests of an annealed coil show 66B at one part and 42B at another part.

In examining the design features pertaining to the narrow strip mill annealing equipment, three things are markedly different from the equipment used in the larger mills.

First, all of these installations use oil seals between the inner cover and the base. The grit from sand, moved throughout the charge more than usual by the high velocities of gas movement, is particularly objectionable to the narrow mill operator. The grit could be carried on the strip to the temper mill where it would scratch the rolls and then spoil the surface finish of the strip. The narrow strip industry in the main uses the oil seal to eliminate the objections to the use of sand for sealing. In high carbon strip annealing, the oil seal is a necessity for accurate atmosphere control and for eliminating the possibility of introduction of decarburizing elements (CO_2, water vapor, or oxygen) by partial pressure exchange. A word on this point will be of interest to explain this phenomenon of partial pressure exchange. Since oxygen (O_2) is 20 per cent of the air, the partial pressure of O_2 in air is 0.20 x 14.7 lb = 2.94 lb. In the absence of O_2 molecules in the annealing gas, the internal pressure under an inner cover would have to exceed this pressure figure to keep oxygen from moving through a sand seal or any leak in the atmosphere system. This will explain why direct firing of furnaces for annealing high carbon steel is not possible with sand-sealed furnaces and nitrogen atmospheres, which are desirable to eliminate explosion haz-

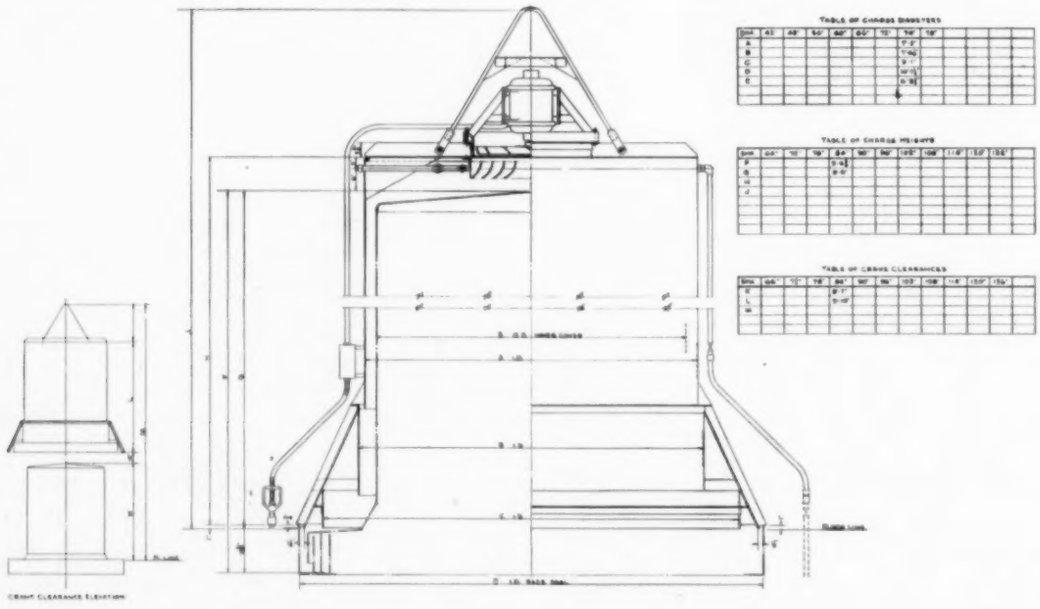


Figure 5—Forced cooler uses air and water sprays to shorten cooling cycle.

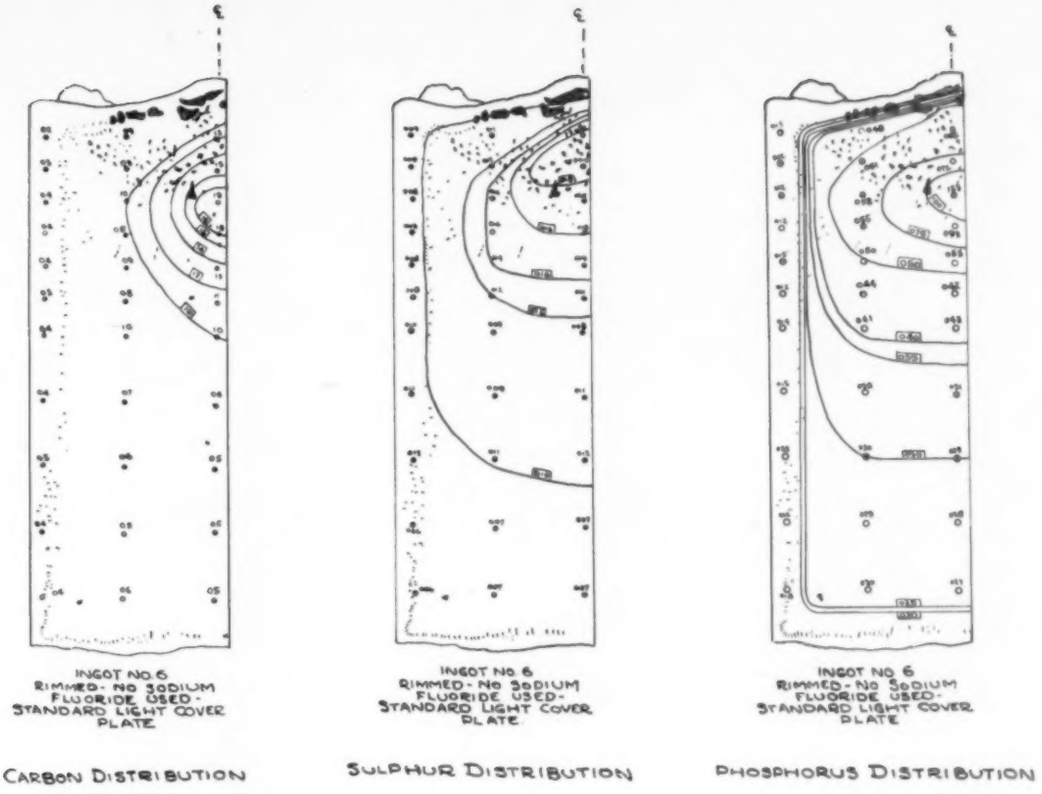


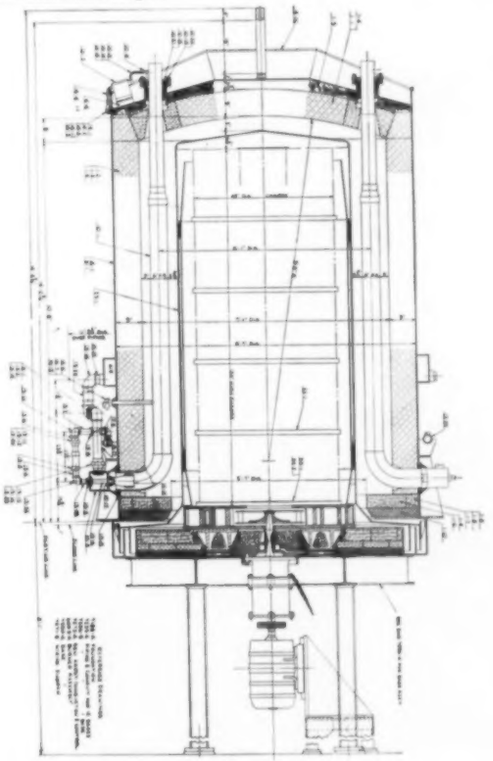
Figure 6 — Segregation of carbon, sulphur and phosphorus is given in this diagram.

ard. The only thing which makes it possible to use direct firing on high carbon steels would be the introduction of H_2 in some form of raw fuel gas, to raise the percent of H_2 to establish a gas equilibrium in the $\frac{H_2O}{H_2}$ ratio and also in the $\frac{CO_2}{CO}$ ratio with the attendent carbon deposit and lack of accurate control.

Second, nearly all annealing installations in the narrow strip industry use alloy inner covers, most of 25-12 chrome-nickel analysis. Since these plants do not produce steel plate from which inner covers could be made and since the inner cover construction at the bottom (Figure 7) is expensive to replace, they have long since adopted the use of alloy covers. Life on these covers for older furnaces with low heat input has been from five years upward. As heat inputs have been increased, the life has shortened, but further study on the differential in temperature on the inner cover face between locations opposite tubes and between tubes for high heat input convection furnaces, has provided a solution by increasing the number of tubes in the furnaces, without increasing total fuel input. This minimizes the temperature differential (Figure 7) between the two areas on the surface inner cover to a point that surface wrinkling has almost disappeared and longer life is assured. A decrease in furnace time of 10 per cent and of course, an increase in furnace production, has resulted from the use of more tubes without using any additional total fuel input.

Third, the narrow strip industry is largely using the full convection system with the inner liner in the inner cover. The use of alloy covers gives a more durable outer shell, and this offers a satisfactory arrangement for use of the inner liner. By definite test, both the heating and cooling time are approximately 15 per cent shorter with the use of the inner liner than without it. If the inner liners distort in time, they are made from mild steel and can be removed, rerolled and reinstalled. If they are replaced, the expense is nominal. The design has been improved to allow the inner cover and

Figure 7 — Cross-section shows assembly for single stack circular annealing furnace. Charge size is 48-in. diameter x 120 in. high.



the liner to move independently of each other for expansion and contraction. Of course, the inner cover lifts the liner with it when it is transferred.

The convector plates are worthy of some mention. See Figure 8. These coil spacers, in the design in widest

Figure 8 — The shape of the curved vanes in the compensating convectors adjust for the use of radiant heat in the outer wraps of the coil.

use, are best termed "compensating convectors," as the shape of the curved vanes is such as to compensate for the use of radiant heat in the outer wraps of the coil. The design of the plates is proposed to heat less by convection where radiant heat is more effective, and more by convection as radiant transfer is less effective. The shape of the vanes in the main is to maintain a constant mass velocity of the gases throughout the path against the coil edges except as convected for the different values of radiation and convection. The actual ratio, as best determined by theory and practice, is 25 per cent radiation and 75 per cent convection. See Figure 9.

Figure 9 — Stack of steel coils shows convector locations.

The fan drives in most general use in the narrow strip industry use an impeller type wheel which moves approximately 8000 cfm at 10 in. static pressure. Most of the static pressure is consumed in achieving high gas velocities between the inner cover and the liner and through the convector plates. A diffuser system or straightening vane arrangement enables the fan to

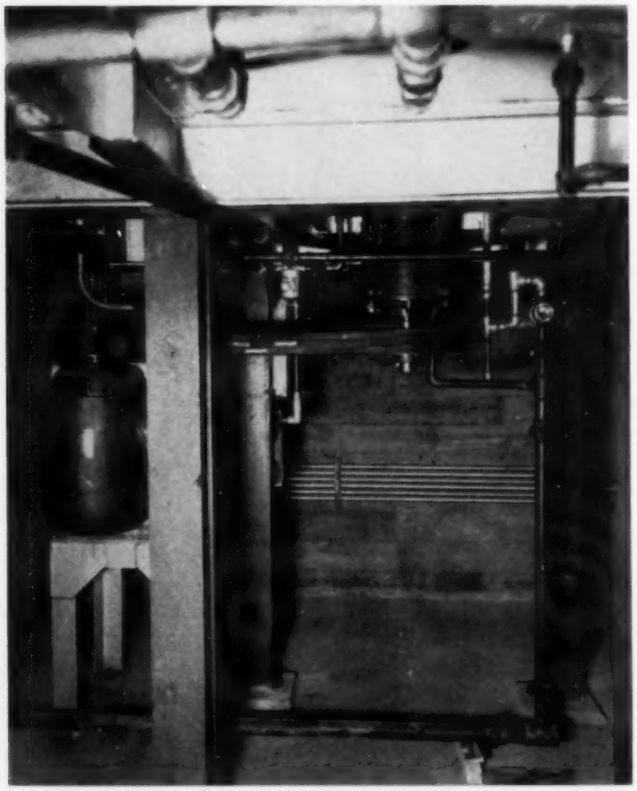


Figure 10 — Fan drive unit is located in the pit.

double the efficiency of operation as compared with just blowing into an open space. The fan drive (Figure 10) employs a standard motor and V-belt drive, so that speed adjustment can be made by changing sheave sizes and standard motors are used. A special shaft seal through which the oil moves to cool and lubricate the top shaft bearing, prevents any leakage of air-in or atmosphere-out. The fan bearing lubricating oil is delivered by gravity from an overhead tank, to which the oil is pumped after filtering and cooling (Figure 11). While this requires an oil piping system, it does assure the cooling of the top bearing for approximately one-half hour if the power fails, and by use of a standby gasoline driven pump, the oil flow can be maintained indefinitely after a power failure.

This type of drive differs somewhat from the unit motor and fan drives used in the larger mills, but offers the use of standard motors and lubrication in case of power failure. The V-belt drive does not detract from the feature of base portability, so desirable in the larger mills; but the smaller mills have much less base main-

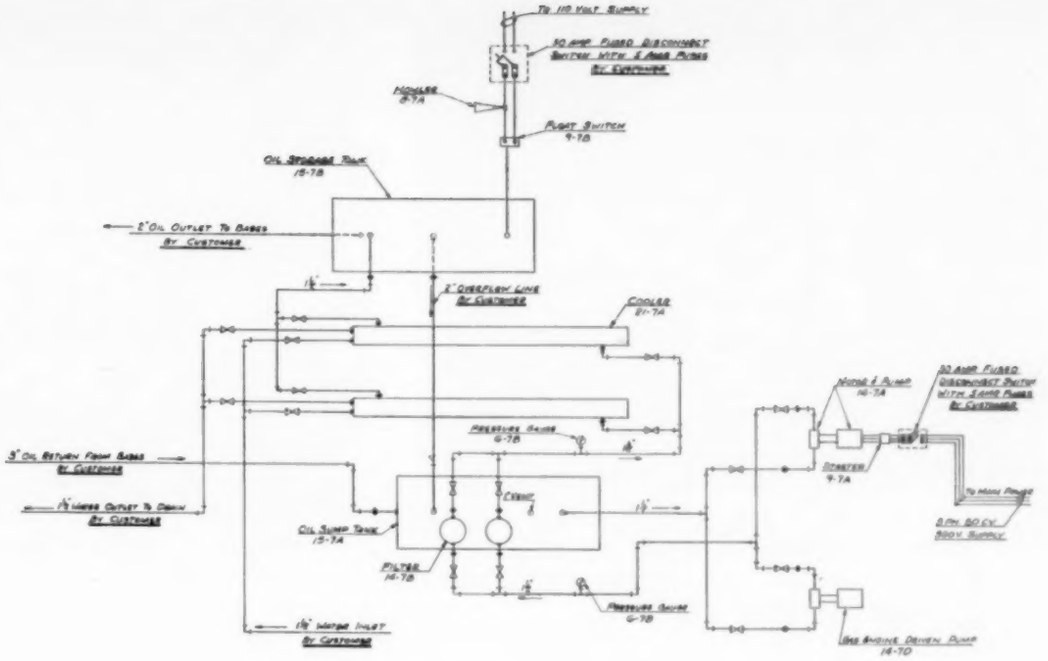


Figure 11 — Schematic piping and wiring arrangement for oil conditioning system.

tenance because the coils are so much lighter, and because the absence of sand for sealing removes a great deal of fan bearing trouble. Therefore, repairs are usually made in place; but the bases could be moved if it were desirable to do so, by using quick disconnect couplings for the oil and deox gas lines.

It will be apparent from the examples of a number of these narrow strip annealing installations that they have been well engineered. See Figures 12, 13, 14, 15 and 16. These are not exactly small plants any more but they would use a lot more floor space and would seem larger if the radiant convection system were not employed.

Figure 12 — A typical single stack annealing installation in which the units are set in a pit.

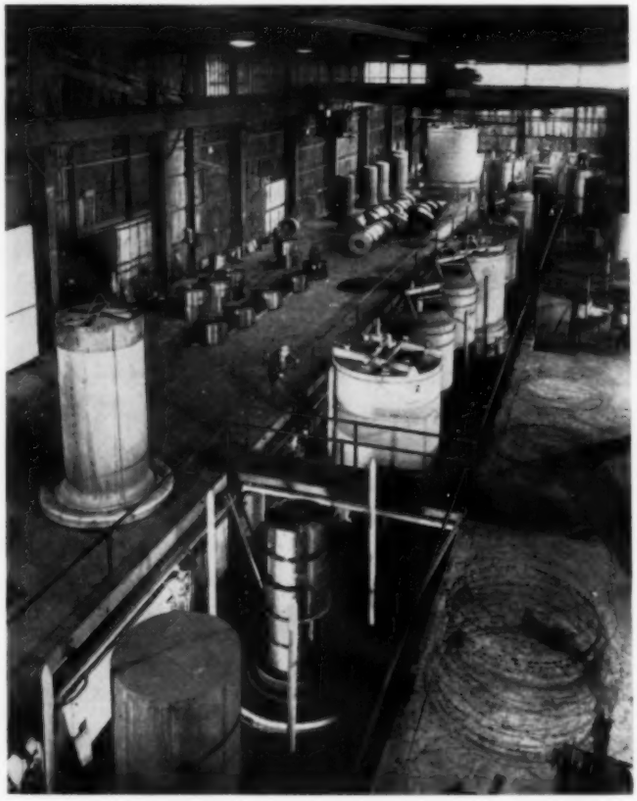


Figure 13 — This installation was designed to anneal coil strip in charges with 48-in. diam and 120-in. high.

Figure 15 shows an installation now being built which will comprise twelve furnaces and thirty bases for coils 66-in. outside diam with a piling height of 150 in. gross. Note the base ratio of 2½ to 1, which the

Figure 14 — Installation shown consists of three furnaces–8 bases for a charge size of 48 in. x 120 in.

relatively faster cooling permits.

Of special interest to alloy manufacturers is the possibility of using this same annealing system with modifications for annealing hot rolled coils of 14 and 7 per cent chrome steel. Special fan wheels, operating at a speed of 1500 rpm, are required for annealing temperatures of 1525 F. As these materials are scaled when annealed, and as the scale must not be reduced, no atmosphere is used. All internal parts are made of 17 per cent chrome to resist oxidation. One such installation of three furnaces and five bases is now under construction, after the process had been tested in an existing

Figure 15 — The faster cooling permits a base-height ratio of about 2½ to 1.

Figure 16 — The narrow strip annealing installations are well engineered.

installation ordinarily used for low carbon steel. The charges will only be cooled before removal to approximately 1000 F, until the material becomes magnetic, so the number of bases used per furnace is lower than for low carbon steel annealing.

The products of the narrow strip mills are different from the large mills. However, the same problem is there, how to make efficiency offset higher costs. The record indicates that the narrow strip mill annealing departments have provided their share of the answer.

DISCUSSION

PRESENTED BY

PAUL W. PHENEGER, Assistant to President, Superior Steel Corp., Carnegie, Pa.

J. L. WHITTEN, Vice President, Lee Wilson Engineering Co., Cleveland, Ohio

Paul W. Pheneger: The author of this very excellent paper is certainly to be commended for having taken cognizance of the difference which exists between the two significant divisions in the steel strip industry. Too often, of late, the small producer or the nonintegrated mill, in particular, has been more or less pushed into the same category with the larger producer. It is much easier, sometimes to deal with the industry as a whole and not consider the numerous problems faced by the small producer together, of course, with the necessity of recognizing or developing a solution for the peculiar problems of the small industry.

Although the equipment builders and suppliers have never lacked recognition of the problems of the small producer, nonetheless the tendency is to provide technical information which is applicable largely to the more spectacular portion of the industry and to allow to go by default the numerous problems of the specialty mills and the small nonintegrated companies.

The author certainly has an excellent insight into the problems of batch annealing, by reason of his long experience in the field. I believe all of us have gained a considerable amount of information and have heard operating clues which can be used to the betterment of

our respective organizations. Mr. Whitten has mentioned that it is most necessary that the narrow strip mill producer keep up to date on technical developments in the field of batch annealing. The truth of this statement is particularly evident when one considers my organization, which is a producer of specialty hot and cold rolled strip steels in a finished width range of from ⅛ in. to 24-in. and in a gauge range of from 0.003 in. to 0.220 in. Embraced in the line of specialty steels are six distinct classifications, which are annealed in batch type furnaces such as the author has described. The specialty classifications are: low carbon steel with carbon below 0.25 per cent; high carbon steel with carbon range of 0.25 per cent to 1.25 per cent; ferritic and martensitic stainless steels, largely in the Type 430 and Type 410 categories; alloy steels; and clad steels.

These six caterogies of steels represent in themselves a wide divergence of annealing problems, but the problem is further complicated by the fact that the clad steel products interject the problems of the annealing of nonferrous metals such as copper, nickel, monel, and both ferritic and austenitic stainless steels simultaneously with the low carbon steel core. It is possible to see that a furnace installation which anneals this variety of product, must be capable of great flexibility as to range of temperature, control of temperature, weight of charge, and variety of atmosphere, while at the same time it must be capable of economical and low maintenance operation.

Correct operation under these conditions is not an easy assignment for either men or equipment, but the specialty mills have met the problems and have solved them almost to complete satisfaction It might be of interest to describe briefly the significant points in the batch annealing practice of the various products mentioned above and to describe the equipment, which is used in these practices. The batch annealing department at Superior Steel Corp. is composed of seven rectangular furnaces, six of which are employed with three bases each, and one with two bases. In addition to the rectangular furnaces, seven cylindrical bell type furnaces with three bases each are employed. Additional non-gas heated furnaces are used, but they will not be discussed at this time. The maximum loads which can be annealed in the rectangular type furnaces are 40,000 lb, while the maximum loads of the bell type furnaces are 15,000 lb. The maximum coil diameter which can be annealed is 42 in.

The capacity of these furnaces is 1,000 lb per hr with the exception of use for full spheroidization, where the capacity is somewhat lower. It can be seen that these furnaces, the first one of which was installed in 1936, do not come precisely within the meaning of modern equipment, as described by Mr. Whitten insofar as capacity per hour is concerned, nor even insofar as heat input is concerned, but they are, none the less, more than adequate for the order size of product found in a specialty mill, our specialty mill particularly, and have proved to be excellent pieces of equipment in which to make a quality product. From the first furnace installation which was, to the best of our knowledge, the primary installation of its type in the country, we have had fifteen years of trouble-free, high quality operation.

The temperature ranges in annealing the six categories of product mentioned here are as follows: low carbon steel—1200 to 1250 F; high carbon steel—1250 to 1320 F; ferritic stainless and martensitic stainless clad metals—1220 to 1350 F. It is obvious that this range of temperature produces a severe strain upon furnace lining, but strangely enough, furnace life, while not so good as that found in a single product, low carbon steel annealing installation, is quite satisfactory because of careful handling and attention.

Three types of atmospheres are employed in this annealing installation. The ferritic and martensitic stainless steels are annealed with air atmosphere and, perhaps, needless to say, with no inner cover. The low carbon steels and some clad metals are annealed with deoxidizing gas, whereas other clad metals, high carbon steels, and alloy steels are annealed with a dissociated ammonia atmosphere. Oil seals are employed on all the furnaces.

One of the interesting features of this annealing installation is that of temperature control. We employ four thermocouples per load in our multiple stack rectangular furnaces and two thermocouples per load in our single stack ball type furnaces. Our controls are so arranged that the hottest thermocouple controls the charge and thus insures proper annealing of all products. This feature, which was at the time of its installation a rather uncommon one, is credited with the correct processing of many tons of material which, otherwise, would have been improperly annealed.

Mr. Whitten has mentioned the desirability of the use of convector plates. We agree that the convector plate is a real stride forward in the annealing art. However, being a narrow strip mill, we have found a compensating factor in the annealing of narrow width strip which has thus far not necessitated our using them. In mills where the width of strip is sufficiently great that only a relatively few coils can be placed in a single stack, the use of the convector plate would be almost a necessity. However, in annealing relatively narrow strip, the pile is sufficiently irregular, and the diameters of the coils vary enough to permit a considerable degree of edge exposure and heating. Theoretically and perhaps practically the use of convector plates might improve this method still more. We would be very much interested to hear of the experiences of other narrow strip mills in connection with the matter.

J. L. Whitten: Mr. Pheneger has made a very interesting comment and reduced some of my generalities to specific cases. I only wish to answer the point about the convector plates. I do not think they would serve any purpose unless the full convection system is used with them; that is, with the high capacity of 15-hp motor to drive the gases through the plates. If that size motor were available to drive some 8000 cfm of gases under the cover at such high velocities, the convector plates would place the heated gases between the coils where they would do the most good. Of course the convection furnace is designed to heat coils as large as possible, but it is all right for use in annealing coils as small as 42 in. outside diam. If these 42-in. outside diam coils could be double wrapped to larger outside diameters the convector plates and higher convection system would give much greater yields than if single coils were used.

Combustion Gas Turbines

By W. B. WILSON
Application Engineer
Industrial Power Div.
General Electric Co.
Schenectady, N. Y.

. . . . gas turbine units have been developed which will give efficiencies ranging from 16 per cent for the simple-cycle unit to 26.5 per cent for the compound-cycle unit . . . .

▲ THE iron and steel industry is one of the largest industrial users of electric power. In many plants, large quantities of "low-cost," by-product fuel are also available. Because of these two facts, power purchased from the utility is often supplemented by power generation within the mill. Steam turbines are also extensively used for blower drives and other mechanical drive applications.

An important new tool for the power engineer in the steel industry is the combustion gas turbine. It is a very simple, self-contained, prime mover and, based on experience to date, it is expected that the gas turbine will compare very favorably with other prime movers from the standpoint of maintenance.

Cooling water requirements are relatively low—approximately 300 to 350 gpm for the 4000-kw simple and 3500-kw regenerative cycle units and 1100 gpm for the 5000-kw compound cycle units. This is one-tenth to one-fourth that required by a condensing steam-turbine plant.

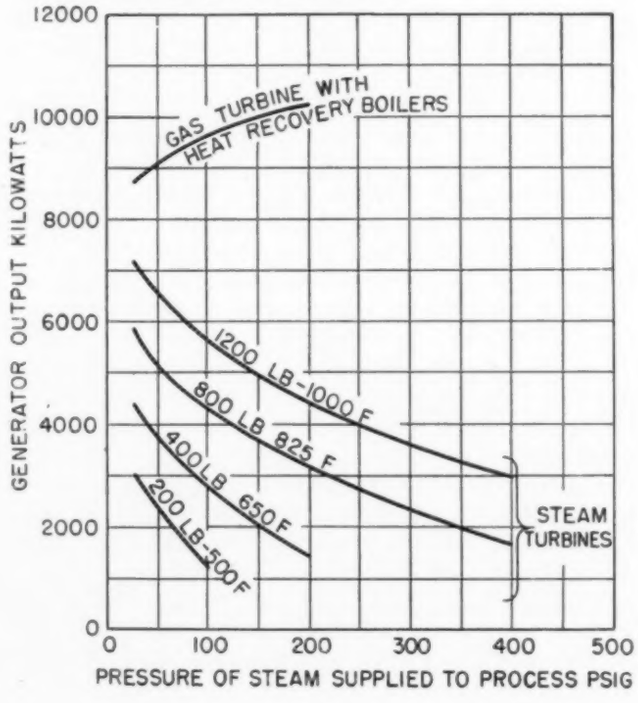
The simplicity, space requirements, low first cost and expected low maintenance and operating costs of combustion gas turbines make them applicable for electric power generation, and for various mechanical drive applications such as to drive blowers and compressors in steel mills.

The use of process or low pressure (200 psig and below) steam is small in most steel plants but, even so, there are many applications where additional electric power and some process steam is required. Gas-turbine units operating in conjunction with exhaust-heat recovery boilers can supply both the electric power and the process steam required at high cycle efficiencies. As shown by the curves, Figure 1, the ratio of kilowatts generated by gas turbines per unit of steam production is high compared to the output of noncondensing steam turbines exhausting to supply process steam requirements. These curves are based on noncondensing steam turbines or gas turbines with exhaust-heat recovery boilers supplying 100,000 lb of steam per hr.

For this steam usage, the gas turbine output is approximately 10,000 kw and steam turbine output ranges from 2500 to 5000 kw, depending upon steam conditions.

Steam power-plant cycle efficiency is highest and the combined cost of steam and power generation within the plant is lowest, when the electric power can be

Figure 1 — Electric power which can be generated by simple-cycle gas turbines and steam turbines when supplying 100,000 lb of steam per hour for process requirements is given by curves.



generated as by-product power using noncondensing or extraction-type steam turbines or gas turbines with exhaust-heat recovery apparatus to supply the steam required for process. The power plant cycle efficiency decreases, and the combined steam and power costs increase when it becomes necessary to generate "condensing" power. The extra kilowatts available from the gas turbine cycle can minimize the "condensing" steam power required and improve the over-all power plant efficiency.

Other gas-turbine cycle arrangements can be used to further improve the over-all power-plant cycle efficiency in many cases. Before going into the details of these gas turbine applications, let us first say a few words about the gas turbine itself.

WHAT IS A COMBUSTION GAS TURBINE

The combustion gas turbine is a very simple, self-contained prime mover. A simple open-cycle combustion gas turbine is shown diagrammatically in Figure 2. It includes the compressor, combustion equipment for

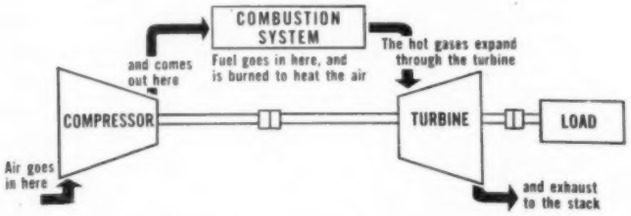

COMBUSTION SYSTEM
and comes out here
Fuel goes in here, and is burned to heat the air
The hot gases expand through the turbine
COMPRESSOR
TURBINE
LOAD
Air goes in here
and exhaust to the stack

Figure 2 — Schematic diagram of a simple-cycle gas-turbine unit.

the burning of fuel and the turbine. Atmospheric air is compressed in the compressor and then passes into the combustion chambers. In the combustion chambers, fuel is mixed with air required for combustion and also with excess air required to maintain combustion gases within temperature limits.

These combustion gases are expanded through a turbine and are exhausted to atmosphere either direct or through various types of exhaust-heat recovery apparatus.

COMMERCIAL APPLICATIONS IN EUROPE

Some European manufacturers have been very active in the gas turbine field. A gas turbine for power generation, driving a 4000-kw generator, was installed in Switzerland about 1939. A locomotive gas turbine of approximately half this rating was placed in service about 1941. Other units have been installed since.

COMMERCIAL APPLICATIONS IN THE UNITED STATES

The first non-military applications of combustion gas turbines in the United States were in 1949. These included a gas-turbine-powered electric locomotive used on the lines of the Union Pacific Railroad and a gas turbine used for power generation in a station of the Oklahoma Gas & Electric Co. Other units are now in service in stations of the Central Maine Power Corp., the Bangor Hydro-Electric Co. in Maine, the Central Vermont Public Service Co. and the Public Service Co. of Oklahoma.

In addition to the gas-turbine units now in service, as listed above, more than fifty combustion gas turbines are on order from us at the present time. Over half of these units will be used for driving compressors on natural gas pipelines.

GAS TURBINE DESIGNS AVAILABLE

Many different cycle arrangements have been considered for the gas turbine. There is the open cycle, in which atmospheric air is used once in its passage through the compressor and turbine; the closed cycle where the same atmospheric air is used over and over and is heated from an external source; and combinations of the two in varying degrees. The efficiency of any of these cycles will depend upon the extent to which intercooling, regeneration, and other refinements are employed.

When all things are considered, the open-cycle arrangement has many very desirable features and this is the cycle selected for the first units developed by our company.

Three types of combustion gas-turbine units have been developed by us for industrial, locomotive, pipeline pumping, and utility applications. These include:

1. A simple-cycle unit rated 4000 kw. A cross-section is shown in Figure 3.

In this unit, atmospheric air is compressed to approximately 65 psig in the compressor, fuel is mixed with the air and burned in the combustion chambers and then expanded through the gas turbine. The turbine drives the compressor at approximately 6700 rpm

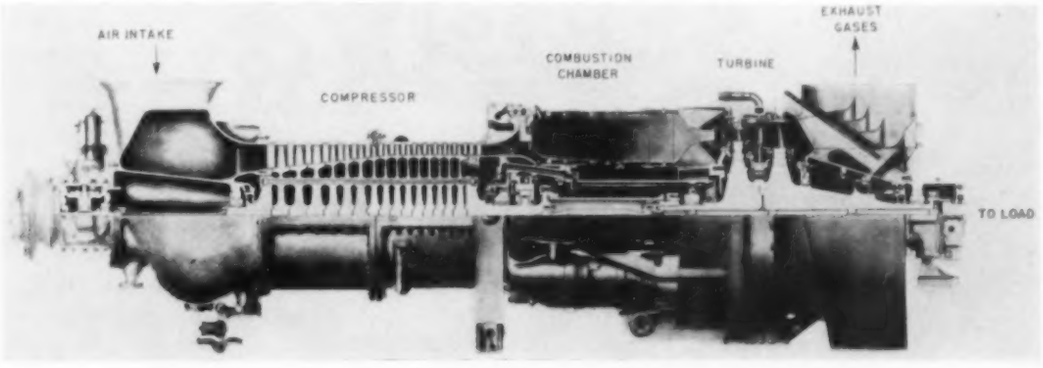


Figure 3 — Cross-section of a 4000-kw, simple, open-cycle gas turbine.

through a coupling at the high-pressure end and the load through a coupling at the exhaust or low-pressure end. Gas-turbine units may be used to drive mechanical loads direct or through suitable reduction gears such as are used when driving generators.

Note the rugged, compact construction of this unit and also take note that the maximum pressure of the gases is only 65 psig compared to modern steam plants where steam pressures range up to 2000 psig or above. The combustion gas turbines for commercial land application are designed with safety factors comparable to those used in steam turbine design, so far as long life and low maintenance are concerned.

This is the type of gas turbine used for locomotive applications.

A gas-turbine power plant of this type, as installed for electric power generation in a plant of the Central Maine Power Corp. is shown in Figure 4. The same

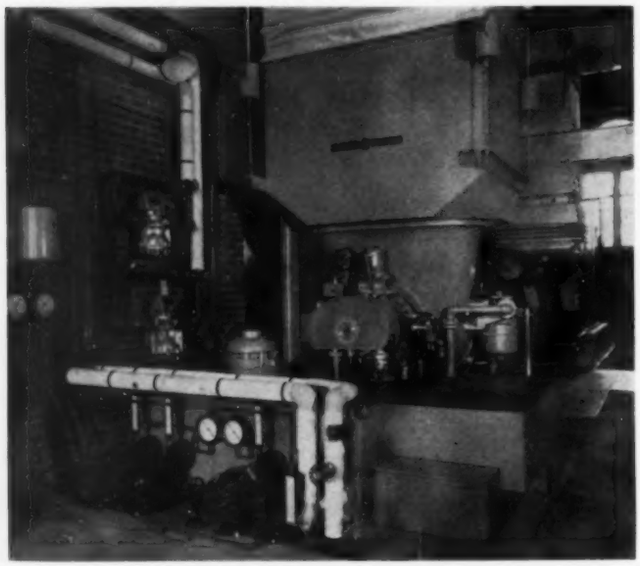
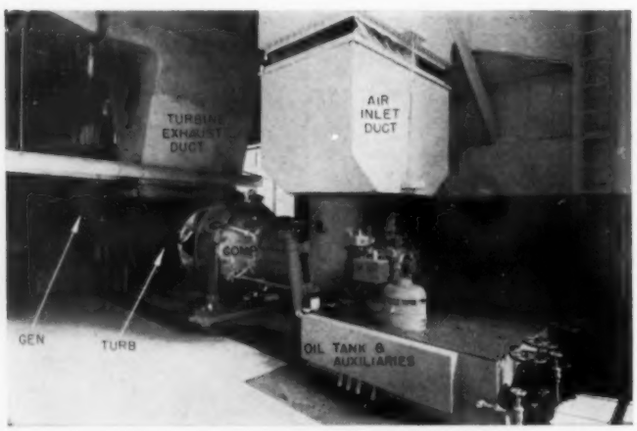


Figure 4 — This 3500-kw gas-turbine generator is located at the Farmingdale Power Station of the Central Maine Power Corp.

type of unit installed in a plant of the Oklahoma Gas & Electric Co. is shown in Figure 5. This is a gas-turbine-generator unit complete with all required auxiliaries, compactly arranged and requiring a floor area of only 8 ft 9 in. x 47 ft. No basement is necessary and the required foundation is very simple.

Gas-turbine power-plant cycle efficiency for the

Figure 5 — A 4000-kw gas-turbine generator set operates at the Belle Isle Power Station of Oklahoma Gas & Electric Co.



Oklahoma installation was approximately 65 per cent because heat recovered from the exhaust gases is utilized to heat feedwater for an existing steam plant. A view of this heat-recovery equipment is shown in Figure 6, located just outside the turbine room, with the gas turbine exhaust gases passing through the feedwater

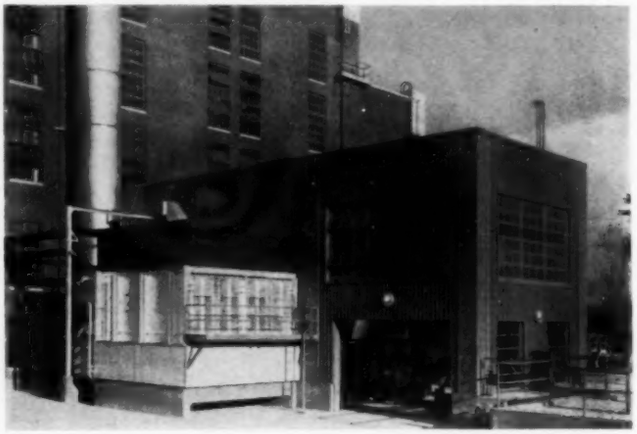


Figure 6 — Building housing 4000-kw gas-turbine set at the Belle Isle Power Station of the Oklahoma Gas & Electric Co. Exhaust-heat recovery equipment is located outside the building in the left foreground.

heater and exhausting to atmosphere through the stack in the background. Heat recovery from the exhaust gases of a 4000-kw unit of this type, in reasonably sized feedwater heaters or waste heat boilers, is approximately 40,000,000 Btu per hr.

When using an exhaust-heat recovery boiler, this is equivalent to 35,000 to 40,000 lb of steam per hr at pressures up to 200 psig.

Greatest field for application of the simple open cycle unit is where space and weight are of prime importance, such as in a locomotive, where a unit is required for standby service such as to supplement a hydro system or to take peak loads, where fuel costs

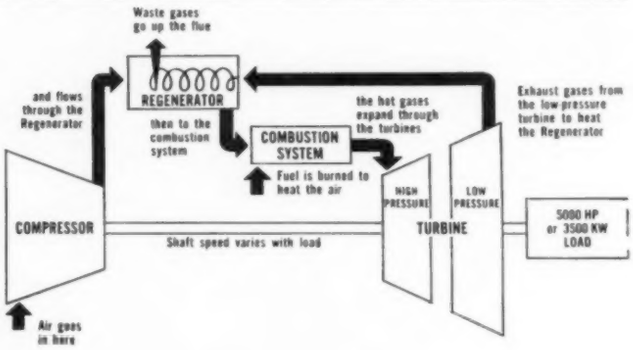

Waste gases go up the flue
and flows through the Regenerator
REGENERATOR
then to the combustion system
COMBUSTION SYSTEM
the hot gases expand through the turbines
Exhaust gases from the low-pressure turbine to heat the Regenerator
Fuel is burned to heat the air
HIGH PRESSURE
LOW PRESSURE
COMPRESSOR
TURBINE
5000 HP or 3500 KW LOAD
Shaft speed varies with load
Air goes in here

Figure 7 — Schematic diagram of a regenerative-cycle gas-turbine unit.

are low, or where there is a use for heat energy which can be recovered from the exhaust gases.

2. Cycle arrangement of a regenerative-cycle unit rated 3500 kw is shown in Figure 7 and a cross-section of the unit in Figure 8.

The gas-turbine power plant actually consists of two turbines—the high-pressure turbine driving the compressor and the low-pressure turbine driving the load.

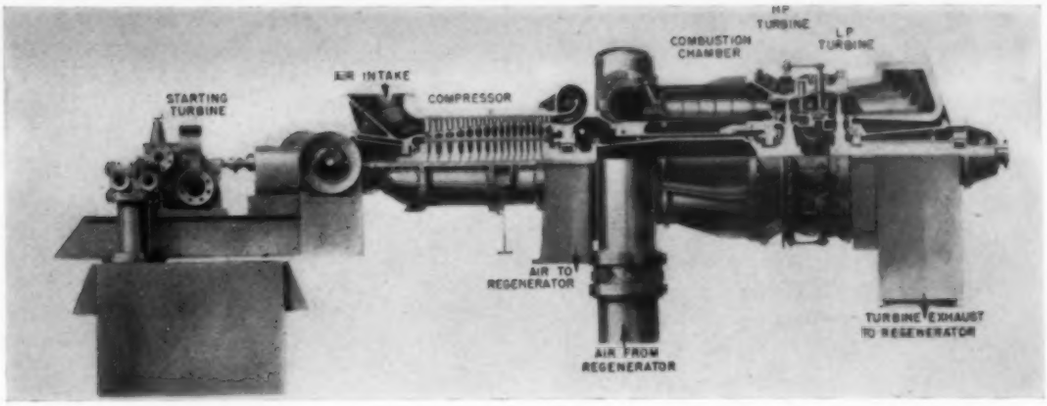


Figure 8 — Cross-section through a 3500-kw regenerative-cycle gas-turbine unit.

Both turbines are located in the same casing, thus eliminating high temperature external gas piping.

Like the simple-cycle unit, this 3500-kw regenerative-cycle gas-turbine generator unit requires a floor space less than 10 ft wide and approximately 50 ft long.

The regenerative-cycle gas turbine is suitable for variable speed drive applications, as well as for constant speed drive applications. In addition to its use for power generation, most of these units have been sold for natural gas pipe-line pumping stations to drive 5000-hp compressors.

An artist's rendering of a gas pipe-line station with two 5000-hp gas turbine driven compressors is shown

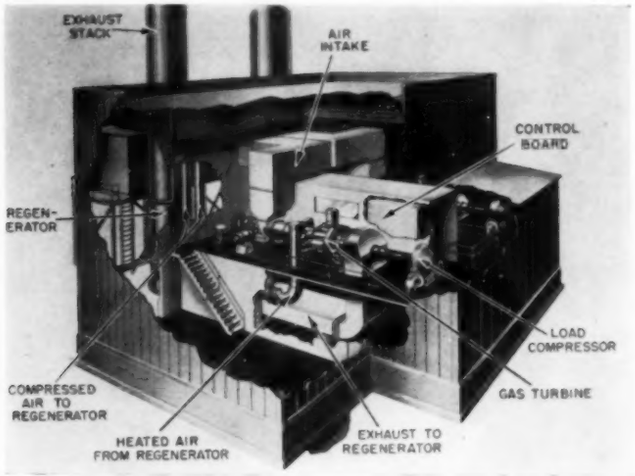


Figure 9 — Artist's sketch of a two-unit gas-turbine powered, natural gas, pipeline-compressor station.

in Figure 9. The regenerators are furnished as a part of the turbine equipment and serve as a base for the exhaust stack. In this arrangement, air ducts to compressor suction come in overhead. The turbine exhaust duct and the air ducts to and from the regenerators are arranged below the turbine. This type of unit can be used to generate process steam by using an exhaust-heat recovery boiler instead of the regenerator. This type of unit is also suitable for various mechanical drives, including variable speed applications.

3. Cycle arrangement of a compound-cycle unit rated 5000 kw is shown in Figure 10 and a cross-section of the unit in Figure 11.

In this unit we also have two turbines, the high-pressure turbine driving the high-pressure compressor and

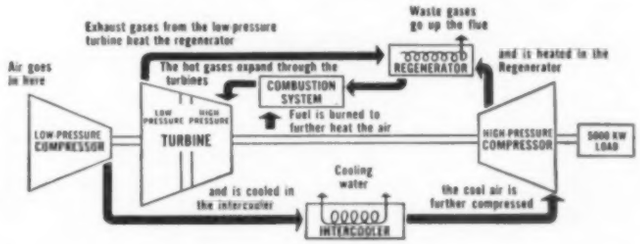

Exhaust gases from the low pressure turbine heat the regenerator
Waste gases go up the flue
Air goes in here
The hot gases expand through the turbines
COMBUSTION SYSTEM
REGENERATOR
and is heated in the Regenerator
Fuel is burned to further heat the air
LOW PRESSURE COMPRESSOR
LOW PRESSURE
HIGH PRESSURE
TURBINE
HIGH PRESSURE COMPRESSOR
5000 KW LOAD
Cooling water
and is cooled in the intercooler
the cool air is further compressed
INTERCOOLER

Figure 10 — Schematic diagram of a compound-cycle gas-turbine unit.

the load, and the low-pressure turbine driving the low-pressure compressor. Intercoolers are located between the low-pressure and high-pressure compressor to cool the air and reduce the work of compression. Regenerators heat the air after the final stage of compression before it enters the combustion chambers and further reduces the fuel required by recovering heat from the exhaust gases.

Compressors and turbines have the same rugged construction as the 3500 kw and 4000 kw units. The combustion chambers are similar and even though we have both a high-pressure and a low-pressure turbine, high temperature external gas piping is eliminated by placing both turbines in the same casing.

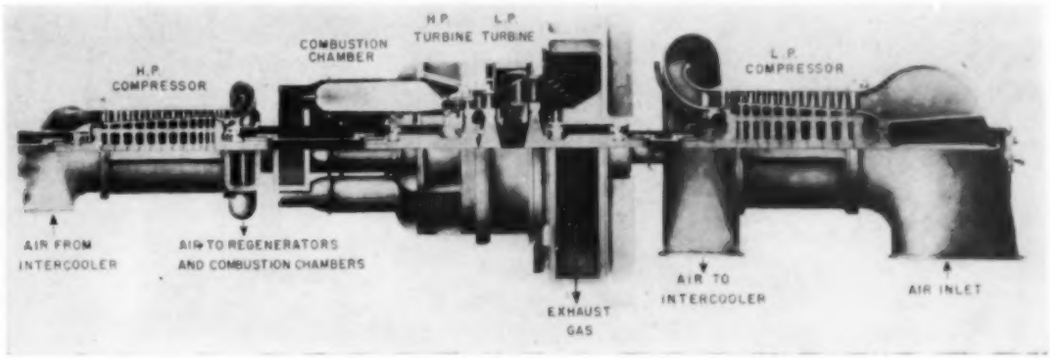


Figure 11 — Cross-section of gas turbine for 5000-kw turbine-generator set.

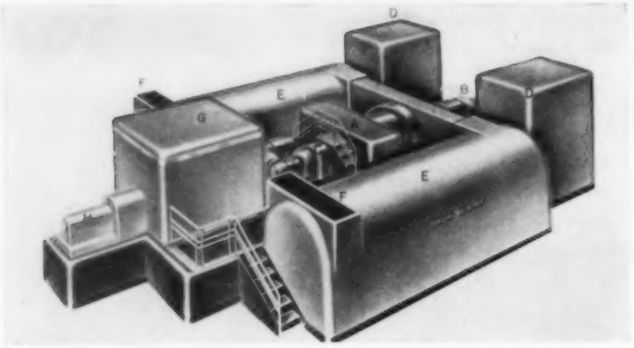


Figure 12 — In this artist's sketch of a 5000-kw compound-cycle, gas-turbine generator set. A is the gas turbine, B is the low-pressure compressor, C is the high-pressure compressor, D are the intercoolers, E are the regenerators, F are the exhaust ducts, G is the generator and H is the exciter.

An artist's rendering of this 5000-kw power plant is shown in Figure 12. This shows the gas turbines and compressors, the generator with its direct-connected exciter, the intercoolers and the regenerators. Figure 13 shows a power plant of this type on test in the factory before installation in a plant of the Central Vermont Public Service Co. in Rutland. This unit requires a floor area of only 27 ft-10 in. x 49 ft-8 in. A unit of this type, in service in a plant of the Bangor Hydro-Electric Co. in Maine, is shown in Figure 14. Another unit is installed in a plant of the Public Service Co. of Oklahoma.

This type of unit was designed primarily for power generation only. Temperatures of the exhaust gases are too low for generation of an appreciable quantity of steam in exhaust-heat recovery boilers.

The efficiency of these gas-turbine generator units, operating without additional exhaust-heat recovery apparatus, ranges from approximately 16 per cent for the simple-cycle unit, 22.5 per cent for the regenerative-cycle unit, to 26.5 per cent for the compound-cycle unit. These efficiencies are based on the higher heating value of the fuel and differ primarily because of the degree of intercooling and regeneration employed.

When heat can be recovered from the turbine exhaust gases for use in process, then power-plant cycle efficiency may be just as high when using the simple-cycle unit as when the compound-cycle unit is used. It is simply a matter of selecting the type of unit which will give the best over-all plant heat balance for each particular application.

Data on temperatures and flows included in Figure 15 for the various types of gas-turbine units will be useful in studying exhaust-heat recovery applications.

Approximate fuel consumptions for the units shown in Figure 15, 16, and 17 respectively, are as follows:

86 million Btu per hr for the simple-cycle unit.

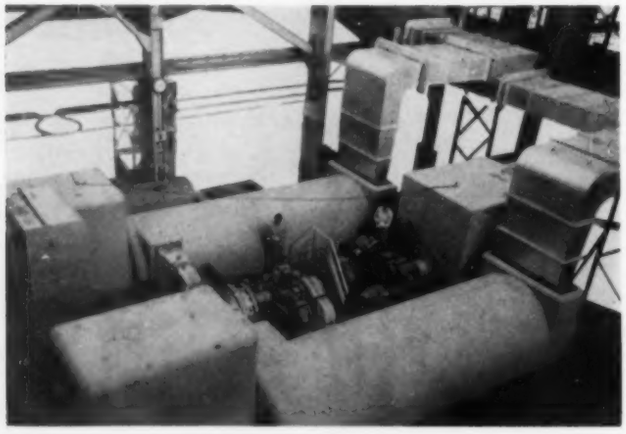
54 million Btu per hr for the regenerative-cycle unit.

65 million Btu per hr for the compound-cycle unit.

These approximate values are based on the high heating value of distillate oil fuels and output at the generator terminals. Actual fuel consumption will depend upon the relation between gross and net values of the fuel actually used.

One interesting characteristic of the gas turbine is the effect of ambient temperature on its output; the lower the temperature, the greater the output. For a decrease in ambient temperature of 40 to 50 F, the turbine output is increased approximately 25 per cent.

Figure 13 — A 5000-kw, compound-cycle, gas-turbine generator set for Central Vermont Public Service Co. is shown on test.



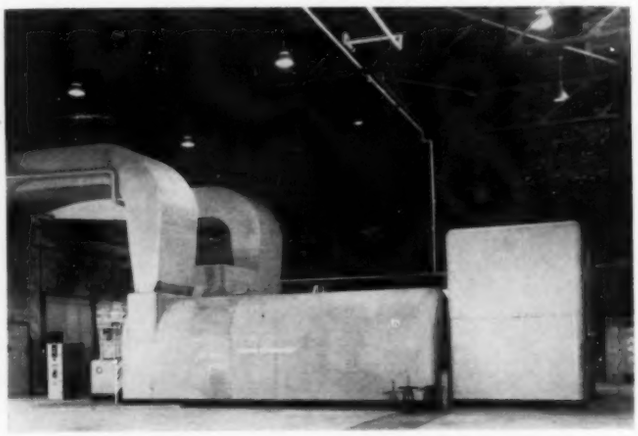


Figure 14 — This 5000-kw gas-turbine generator set is installed at a station of the Bangor Hydro-Electric Co.

APPLICATIONS

The three types of combustion gas turbines described above and now in commercial production have application in many industrial plants as well as in utility plants. The design and operating experience gained on these units will be of great value in the design of other units suitable for an even wider field of application in the steel industry in the future.

You may look for additional gas turbines to fit even more power applications in the future but, in the meantime, let us take full advantage of the units now available. As stated earlier, efficiency of the gas-turbine units now available ranges from 16 to almost 27 per cent without additional exhaust-heat recovery apparatus. These efficiencies are based on the higher heating value of the fuel, and output at the generator terminals. You will find that the efficiency of the 5000-kw compound cycle unit is right at the top when compared with other types of plants having equal rating.

The efficiency, simplicity, first cost and expected low maintenance and operating costs for the gas-turbine units now available make them particularly applicable where additional electric power or mechanical power in blocks of 3500 to 5000 kw is required.

Where continuous process operations are a "must," as some of steel's are, the gas turbine with its quick starting characteristics can be used for emergency, or for peak load service even in plants where it is not used to supply the normal daily plant load.

The following is a brief summary of some of the ways these gas-turbine units can be applied to help supply mill requirements for steam and electric power.

EXHAUST-HEAT RECOVERY BOILERS

Figure 1 shows the relation between the gas-turbine generator kilowatt output and the steam output from the exhaust-heat recovery boilers and immediately suggests an application for steam generation.

The arrangement for one mill requiring both process steam and electric power is shown in Figure 18. Heat in the gas turbine exhaust gases was to be recovered for the generation of steam in two boilers at two differ-

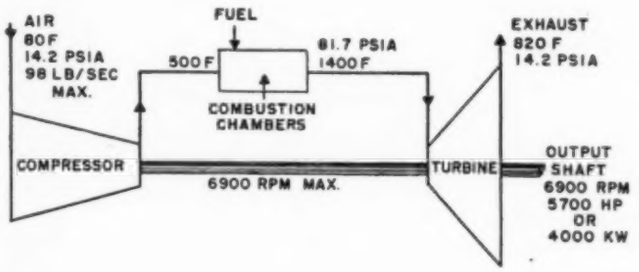


Figure 15 — Pressures, temperatures and flows through 4000-kw, simple-cycle gas turbine are given in this schematic diagram.

ent pressures—175 psig and 40 psig. From the last boiler, the exhaust gases pass through an economizer to heat feedwater for the boilers before exhausting to the stack. This arrangement would provide a total of 39,000 lb of steam per hr and 3500 kw of electric energy. This is a ratio of approximately 11 lb of process steam for each kwhr. Over-all gas-turbine plant cycle efficiency for this steam and power generation is approximately 70 per cent.

These requirements could also be supplied by a double automatic-extraction-condensing steam turbine plant. Over-all plant thermal efficiency of the steam-turbine cycle would be approximately 52 per cent. This is lower than the gas-turbine plant efficiency for this particular application, because the ratio of process steam to electric power is low and a high percentage of the electric energy must be produced by the condensing section of the steam turbine which operates at a plant thermal efficiency of only 20 to 25 per cent. (If the process steam requirements were appreciably greater, then the efficiencies of the two cycles would be comparable).

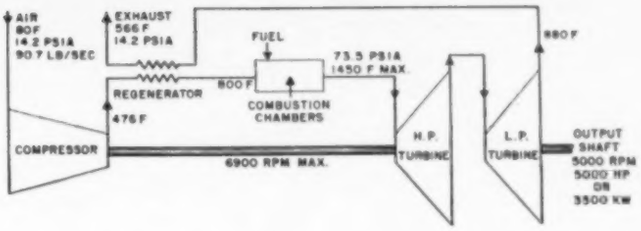


Figure 16 — Pressures, temperatures and flows through 3500-kw, regenerative-cycle gas turbine are given in this schematic diagram.

Use of the gas turbine (the simple-cycle with exhaust-heat recovery boilers or the regenerative-cycle with exhaust-heat recovery boiler used in place of the regenerator) with its higher cycle efficiency for this application would result in a fuel saving of over $60,000 per year based on a plant factor of 80 per cent and a fuel cost of 30 cents per million Btu. Initial cost of the gas-turbine plant should be lower and the cooling water requirements would be about one-tenth that required by a condensing steam-turbine plant of the same kw rating.

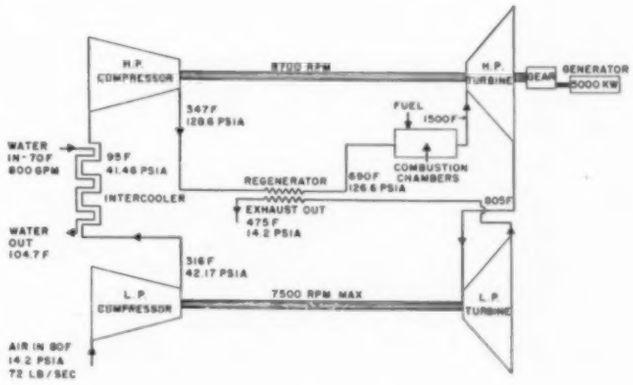
SUPPLEMENTARY FUEL FIRING

When required, steam flow from the exhaust-heat recovery boilers can be increased by supplementary fuel firing.

Therefore, the gas turbine can be applied where the ratio of kilowatts to process steam (Figure 1) is higher than the upper limit of the noncondensing steam plant, but lower than the gas turbine operating with exhaust-heat recovery boilers alone (steam turbine 20 to 40 and gas turbine 10 to 12 lb process steam per kwhr). This is the area where by-product power generation would have to be supplemented by "condensing" power in a straight steam-turbine plant.

In this case of supplementary firing, heat recovered from the gas-turbine exhaust gases is supplemented by heat from additional fuel burned in the turbine exhaust

Figure 17 — Pressures, temperatures and flows through 5000-kw, compound-cycle gas turbine are given in this schematic diagram.



gases between the turbine and the exhaust-heat recovery boiler. The additional cost of providing for this supplementary fuel firing is low compared with the greatly increased flexibility of operation it affords. All that is necessary is the addition of a section of refractory-lined ductwork and installation of the necessary fuel nozzles just ahead of the exhaust-heat re-

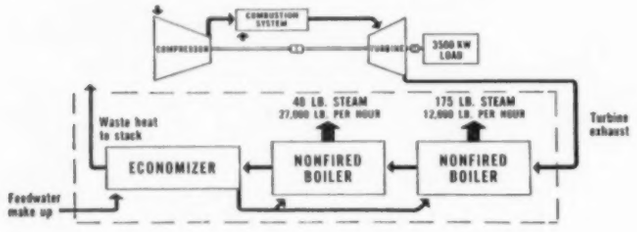


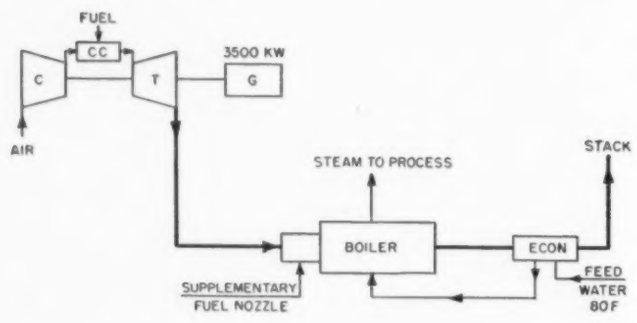
Figure 18 — Schematic diagram of simple-cycle gas turbine with exhaust-heat recovery boilers and economizer to recover heat from turbine exhaust gases.

covery boilers. A schematic diagram for such an arrangement is shown in Figure 19. This shows the exhaust-heat recovery boiler with the fuel nozzles for supplementary firing located just ahead of the boiler. Because of the large amount of excess air (approximately 450 per cent) used in the gas-turbine cycle, no additional air is required for combustion of this supplementary fuel. This further simplifies the installation and operation, because forced-draft fans and their attendant controls are not required.

Depending on the balance between electric power and steam requirements, supplementary firing might be used continuously to increase the output of the exhaust-heat recovery boilers to relieve the demand on conventional fuel-fired boilers. In other mills, supplementary firing might be used to supply occasional peaks in steam load.

In still other mills, supplementary firing might be used during an outage of conventional fuel-fired boilers. The output of the exhaust-heat recovery boilers can easily be doubled or tripled—say, from 40,000 to 80,000 or 120,000 lb per hr steam flow—by supplementary firing. This being the case, the capacity of

Figure 19 — Gas turbine and exhaust-heat recovery boiler have supplementary fuel firing.



fuel-fired boilers normally maintained as standby can be materially reduced with the attendant reduction in first cost and fixed charges.

TURBINE EXHAUST GASES AS COMBUSTION AIR

High gas-turbine cycle efficiencies can also be realized in mills where the combustion gas-turbine exhaust gases can be used as combustion air for fuel-fired boilers. Because of the large amount of excess air used in the gas-turbine cycle to limit temperatures, the turbine exhaust contains approximately 17 per cent oxygen compared to 21 per cent for free air. Because so much oxygen is left in the exhaust gases, they can be used as preheated combustion air for fuel-fired boilers which are not equipped with air heaters. One 4000-kw gas turbine can supply combustion air required for a fuel-fired boiler having an output of approximately 250,000 lb of steam per hr. This cycle arrangement is shown in Figure 20.

When the gas-turbine exhaust gases can be utilized as combustion air for fuel-fired boilers equipped with economizers, the gas-turbine plant cycle efficiency can be as high as 80 per cent when credited with heat in the exhaust gases. For the same per cent excess air in the fuel-fired boilers, boiler stack losses will be slightly higher when gas-turbine exhaust gases are used for combustion air.

GAS TURBINE EQUIPMENT

We have noted how the 3500 and 4000-kw turbine-generator units require a floor area less than 10 ft by 50 ft and the 5000-kw compound-cycle unit an area of approximately 28 ft by 50 ft. What does the customer get when he buys a gas turbine plant?

He of course gets the intercoolers and regenerators when used, with the connecting piping and ductwork. Starting and turbine supervisory controls are provided, as well as equipment for control of the few auxiliary and starting motors which are also furnished with the gas turbine.

So—when comparing a gas turbine plant with a gas engine or steam turbine plant—we must remember that the installation pictures shown are, essentially, the complete gas turbine generating plant.

FUTURE DEVELOPMENTS

Now, as to possible future developments, we are cognizant of the fact that there are many applications in the steel industry where combustion gas turbines in ratings higher than 5000 kw would be very desirable. For generation, a unit rated 15,000 kw should find wide application, particularly if it could use blast furnace gas as its fuel. Likewise, units rated 10,000 to 20,000 hp would make very suitable blower drives. Development of larger units is well underway.

FUELS

Now as to the fuels for combustion gas turbines, this is an item of particular interest. Much effort is being

expended at the present time to develop means of using a wide variety of fuels for the combustion gas turbine. Based on experience to date, gas or distillate oils are excellent fuels. With some minor design changes, the gas-turbine units now in production can be adapted to burn 300 Btu per cu ft gas. It is also expected that plants can be designed for the use of blast furnace gas having a heating value of 90 or 95 Btu per cu ft. No doubt, in the future, satisfactory equipment will be developed so other fuels can be used commercially.

At the present time, the steam-turbine plant can utilize a much wider variety of fuels. This is a handicap for the gas turbine in areas where the cost of suitable fuel is higher than that of fuels for other power plants. This handicap is partially overcome by the greater simplicity and lower installed cost for the gas turbine.

A development scheduled for further study is a unit suitable for the use of blast furnace gas as its fuel. As mentioned earlier, large quantities of excess air are used in the gas turbine cycle just to keep temperature of the combustion air within limits. If the low Btu blast furnace gas is used as fuel, then the inert portion of this fuel will reduce the amount of atmospheric air required for cooling. This would indicate an investiga-

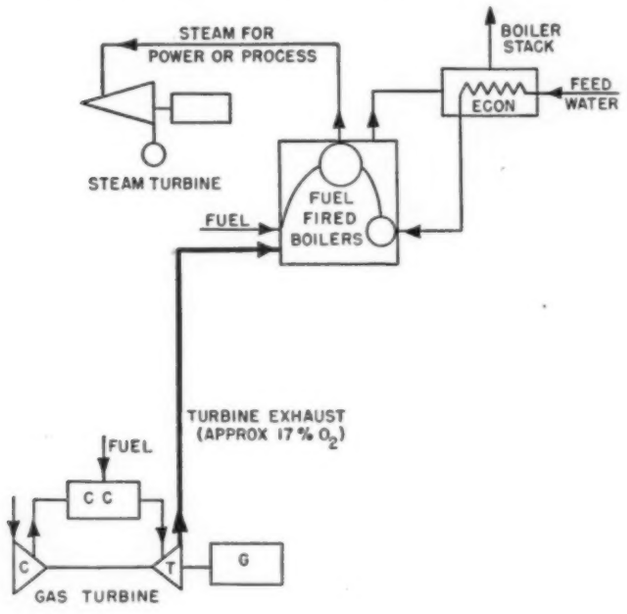


Figure 20 — Gas turbine supplies combustion air for fuel-fired steam boilers.

tion of reducing size of the air compressor and the horsepower required for air compression. This reduction in horsepower can then partially offset the power required for compressing the low Btu blast furnace gas fuel. If the air compressor and the fuel gas compressor can be properly sized, then the additional power required for compressing the air and low Btu blast furnace gas fuel may be relatively small. In this case, the reduction in over-all cycle efficiency would not be great. Another item to be considered is the actual burning of this low Btu fuel and controlling this combustion.

As the saying goes, nothing is impossible, but a problem of this kind does require considerable time and development. The economic aspects of such a development might even indicate the desirability of securing a gas turbine fuel, having a heating value higher than 90 Btu, by enriching blast furnace gas with coke oven gas, natural gas or even fuel oil.

SUMMARY

Let us make a few comparisons between the gas turbine and the steam-turbine plant.

Initial Cost—From available data, it is estimated that cost of a new gas-turbine plant is approximately three-fourths that of a comparable steam plant. However, each case should be carefully studied by competent engineers so accurate and complete installation and operating costs are established. With such information the proper selection of the source of power can be made whether this be purchased power or local generation or a combination.

Control—The gas-turbine plant has one simple control panel shown in Figure 21. The simplicity of this plant makes complete automatic control practical.

Efficiency—When properly applied, both the steam and gas-turbines can operate to supply both process steam and electric power at high cycle efficiencies (the gas-turbine when ratio of electric energy to heat energy is high, and the steam turbine when this ratio is low).

Reliability and Maintenance—A total of more than 30,000 hours of operation have been accumulated on the gas turbines now in service and the service record has been very good. Even though this is equivalent to more than three years of operation, it is realized that an accurate prediction of reliability and maintenance cannot be based on this relatively short period of operation. However, the designers are confident that the gas-turbine plant will compare favorably with the steam-turbine plant. It might be well to point out here that the combustion gas turbines for commercial land applications are designed with safety factors comparable to those used in steam turbine design so far as long life and low maintenance are concerned.

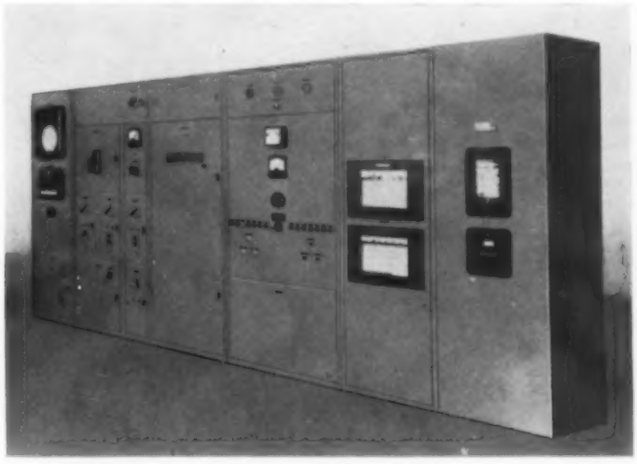


Figure 21 — Typical control panel for a gas-turbine unit.

Based on experience to date and with the above development program in mind, the combustion gas turbine is a new tool that will be of help to the steel mill power engineer in selecting prime movers for new plants or for plant expansions today. It will be of even greater help in the future.

DISCUSSION

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P. F. KINYOUN, Combustion Engineer, Bethlehem Steel Co., Lackawanna, N. Y.

E. A. Hawk: Do they use the same size regenerator for natural gas as for fuel oil on your heat exchanger?

W. B. Wilson: In recovering the heat in the exhaust gases in a heat exchanger that, of course, is a matter of volume flow and keeping pressure drops at a minimum. If we use blast furnace gas, for instance, with its relatively large volume for the same Btu, then the volume flow through the turbine, no doubt, would be increased appreciably and the gas passages through this heat recovery equipment would have to be larger. On the other hand, if a unit is developed such that the quantity of air is reduced almost in proportion to the increased volume flow of fuel, then I believe that the passages in these heat recovery apparatuses would be about the same. In that connection, the size of these heat recovery equipment is, of course, an economic factor. The intercoolers, for instance, on this 5,000-kw unit are designed for an effectiveness of ninety per cent.

The regenerators have been designed for about seventy-five or eighty per cent. One customer who has a 5000-kw unit now in service and others in this heat that he can justify additional investments in this heat recovery equipment, and his next unit will have regenerators even larger with higher effectiveness.

H. O. Bennett: I would like to ask what methods are normally employed to bring these units up to speed.

W. B. Wilson: Furnished with the turbine equipment is a control panel and that can be either manual or automatic. Most of them are at least semi-automatic, in that you turn the dial to the start position and timing relays time out the various cranking and starting functions.

These are engines that have to be cranked, and this cranking power is either from electric motors, or any other source. In the case of units operating in natural gas pipeline compressor stations, a small mechanical-drive turbine which is merely a flow-type gas turbine is used. It takes gas from the main pipeline at high pressure and exhausts it at atmospheric pressure to the flare pit for that few minutes' starting time to give the required power for cranking the main combustion gas turbine.

Now, aside from how you get the power to crank the unit, the starting device accelerates the gas turbine up to approximately $\frac{1}{6}$ to $\frac{1}{3}$ speed and that gives enough air flow from the compressor so fuel can be admitted and the unit "fired off." It has spark plugs to ignite the gases in the first one or two combustion chambers. There are actually six separate combustion chambers located around the unit and cross-fire tubes are located between the different combustion chambers so all of them are ignited from these one or two that have spark plugs. After the unit is "fired," the speed can be brought to speed by control of fuel supply to the turbine.

There is an overriding clutch or other suitable mechanism which automatically disconnects the starting device from the gas turbine as the turbine accelerates under its own power. The turbine can then be loaded in the same way as other prime movers. The time for the 3,500-kw simple-cycle unit has been as low as three and one-half minutes from cold start to full load. A reasonable time is ten or fifteen minutes for that starting cycle.

N. A. Resare: How long has this 5000-kw turbine been in operation, and how was maintenance during that time?

W. B. Wilson: We have had one in service in a plant of the Bangor Hydro-Electric Co. almost one year. It is actually being used as a standby for hydro, and it does not have very many hours on it. Another unit is in service in a plant of the Central Vermont Public Service, and a third unit in a plant of the Oklahoma Public Service. Not very many hours have been accumulated on any of those three units and the troubles have been of a minor nature.

However, I am glad you brought that question up, because the burning of Bunker "C" oil does present some problems not encountered with natural gas fuel. As you know, Bunker "C" oil is a fuel which causes added maintenance on many of our fuel-fired boilers in steam plants. An investigation of the early effects of Bunker "C" fuel on combustion gas turbines indicated that the ash of oil with high vanadium content acted as a fluxing agent to damage the turbine nozzles. Well, various corrective means and additives have been made to the oil and that trouble alleviated. Then another undesirable element is discovered. It has been determined quite definitely that Bunker "C" oils having a high percentage of vanadium or oils having a high percentage of sodium can cause increased maintenance when used as a fuel for combustion gas turbines. If both vanadium and sodium are present in the proper proportions, they seem to counteract the effect of each other, and the problems of burning Bunker "C" is greatly reduced.

So, with Bunker "C" oil there is quite a bit of study yet to be done. It is a problem that is receiving much attention by our engineers.

About 25,000 hours total operating experience has been accumulated on our combustion gas turbines for land applications. The 3500-kw unit at Oklahoma Gas and Electric has fifteen to twenty thousand of those, so you can see that the combined service on other units in service is somewhere around five or six thousand hours.

Member: I would like to ask Mr. Wilson if he would not outline the status of direct-fired, coal-burning gas turbines.

W. B. Wilson: I am not qualified to give you any firsthand information on that coal-burning unit. Mr. Yellot, as you know, has done a lot of work at Dunkirk, N. Y. and elsewhere. Perhaps the first turbine unit used for testing at Dunkirk was a "flow type" gas turbine such as used in the Houdry process with a separate "hot gas generator." I understand another type of turbine has been installed at Dunkirk for further testing. So far as I know, one of the great problems is the abrasive material in the products of combustion of the coal.

One other thing in connection with the use of coal as a fuel for combustion gas turbines is the conversion of coal into a producer gas and then the use of this gas as fuel for the combustion gas turbine. Quite a bit of work has been done along that line. If some simple device can be devised to produce gas at high efficiency, that will, of course, open up another wide field for the application of combustion gas turbines. Right now we are devoting most of our efforts to natural gas and oil.

In connection with this abrasive matter, that, of course, is going to be one of the problems with the use of blast-furnace gas. I do not think it will be a great problem, because, at the present time, blast-furnace gas is well cleaned for use in your stoves and other uses. As someone has said, it is cleaner than atmospheric air so that should not present any problem.

Fred R. Fielding: I would like to know if Mr. Wilson expects any near development of the gas turbine for use with coke-oven gas?

W. B. Wilson: Coke-oven gas has a heating value of about 500 to 600 Btu per cubic foot. I see no reason why coke-oven gas, properly cleaned, could not be used as the fuel for some of our existing gas turbines with very minor changes.

Member: On the velox cycle, as I have seen it, the boiler is used to reduce the temperature of the gases. The gas turbine follows the boiler and the temperature in the gas turbine is, therefore, such that ordinary metals can be used in it and the high temperature is skimmed off by the steam boiler where there is no difficulty. Combustion is under pressure and of much greater efficiency than a normal boiler under atmospheric pressures or slightly higher.

G. H. Krapf: I would like to ask are the ratings at 60 F inlet air?

W. B. Wilson: At 80 F.

G. H. Krapf: What is the effect at higher air temperatures of say 100 F?

W. B. Wilson: The 5,000-kw compound cycle unit is rated 80 F inlet air, but it actually will develop, full-rated, 5,000-kw at 110. Net output of the simple cycle and the regenerative cycle units decreases as the air temperature increases. I am guessing at the curve now, but I would say there is about a twenty per cent reduction in net output when ambient temperature increases from 80-100 F. Now, this matter of 100 F ambient temperature is not so real if we consider that evaporative coolers can be used which will wash the air and cool it down within a couple of degrees of wet bulb. Even though you have a 100 F dry bulb, there are very few places in our country where the wet bulb is much above 80 to 83 very many hours of the year. and with the evaporative cooler, the turbine and compressor can operate with low ambients the year 'round.

E. H. Codding: Would that evaporative cooler be a part of the standard installation?

W. B. Wilson: That equipment is not normally furnished as a part of the turbine equipment. It is being used in the pipeline compressor stations to cool the air in the middle of the desert where temperatures over 100 F are not uncommon. In these areas, humidity is usually low and the air can be cooled to temperatures of 80 F or below most of the time. The cost of these evaporative coolers, circulating about five or six hundred gpm of water, is $9,000 or $10,000. It is not a large item of cost, plus the fact that with evaporative cooling, there is very little makeup water. The availability of cooling water is a problem in some areas.

T. O. Zittel: What time does it take to start a 5000-kw unit?

W. B. Wilson: For the 5000-kw compound cycle with regenerators and inter-coolers, a reasonable timing would be from 20 to 25 minutes. As for the simple cycle unit, such as is installed at the Oklahoma Gas & Electric, that has been started and a full load applied in less than three minutes.

T. O. Zittel: Is it necessary to clean the air required for the gas turbine? A lot of air is required and the air cleaning problem could develop into major proportions.

W. B. Wilson: We have not felt it was necessary to clean the air in very many locations. There are, of course, advantages in cleaning the air to reduce the period of time between possible cleanings of compressor. Another advantage can be achieved by the use of a combined air washer and evaporative cooler. These are used in many of the arid sections for cooling air and increasing the turbine capability. In other words, the simple cycle unit that we have talked about is rated 4000-kw with natural gas fuel and an air temperature of 80 F to the inlet of compressor. The useful turbine output increases at lower temperatures. At the Oklahoma Gas and Electric Co.'s plant, relatively cold well-water is available and they used old generator air coolers which were available to cool the air supply for the gas turbine-generator unit. That is one reason it has been possible to operate this unit at loads above 4000-kw most of the time. With the combined air washer and evaporative cooler mentioned above, air supply to the gas turbine compressor can be cooled down to within about two or three degrees of wet-bulb temperature, which means quite a lot in many areas. So, cooling and cleaning the air can be an advantage in many areas.

Edwin Ball: What type ignition do you have in the gas turbine chamber?

W. B. Wilson: It is a spark plug ignition. Two of the combustion chambers, of which there are six located around the circumference of the turbine, have spark plugs in them which fire off. There are cross-fire tubes which then ignite fuel in the other combustion chambers. Now, as the unit comes up the speed, of course, the spark plug is all through with its job. They retract automatically out of the high temperature section. Those combustion chambers are lined with special alloy material, but they operate at a relatively low temperature, because they are designed with air coming on the outside of them, and entering them at various locations down, throughout the length of the combustion chamber.

Flame detectors will automatically detect flame failure and shut the unit down, in case, for any reason, there is an interruption in fuel flow which causes the flame to be extinguished.

It might be of interest to know that the Oklahoma Gas & Electric unit was installed two and a half years ago and, as of December 1951, it had over 18,000 operating hours and an overall average load of 4380 to 4390 kw. Every time we get a report, the overall average output is up. The only replacement parts on that unit were two or three of the flame detectors in the early stages, and the impeller of a motor driven oil pump which caused a 37 hour outage. Out of this 18,000 hours, the only unscheduled outage was caused by failure of this little motor-driven oil pump. Pumps such as this have been made for years and it is a bit discouraging to have that kind of thing shut down a gas turbine that has such an excellent record.

R. P. Moore: I am puzzled as to why the Swiss seem to be so far ahead of us on gas turbines. I believe they have a 27,000-kw unit in operation at the present time.

W. B. Wilson: They do have. I am interested in your statement as to why they are so far ahead of us. I know they do have a lot of units. They have this 27,000-kw unit and the number of operating hours on it is not great. Actually, they have units in service in France and Switzerland and several other places. Their first combustion gas turbine was installed about 1939 or 1940. We had the intervening war years which slowed them down appreciably, I am sure, but I think you will find we have many more total operating hours on a single gas turbine unit in the purchaser's plant than any other manufacturer. So far as the 27,000-kw unit, units are going to be bigger in this country than they are now. It is a matter of walking before running. We would like to get a lot of operating experience with the different units that we have developed and have in service. This experience will be very useful in the development of other units suitable for even more of your applications in the future.

A. S. Merrow, Jr.: In connection with the unit in operation at the Central Maine Power Co., what fuel do they use there, Bunker "C"?

W. B. Wilson: Central Maine is a Bunker "C" unit. In connection with the Bunker "C" oil, I might mention the fact that there are lots of problems with burning Bunker "C" residual oils which are not present when natural gas or distillate oils are used as the fuel. As you know, even with high-temperature steam boilers, there has been an appreciable problem of maintenance when certain residual oils are used as fuel. In some cases the super-heater hangers just seem to disappear. This trouble has been attributed primarily to vanadium bearing residual oils. Now, when it was first experienced in the combustion gas turbine, the natural thing was to suspect the vanadium, and a test of the ash in those units did disclose that they were high vanadium content oils. High sodium content oils can also cause trouble.

Our engineers have made many tests and are determining what is required to minimize the harmful effects of the different troublesome elements. One of the harmful things that is a bit interesting to me is the fact that high vanadium apparently gives us trouble, high sodium gives us trouble, either of them alone, but mix the two of them together in the right proportions and they cause little, if any, trouble.

P. F. Kinyoun: What would be the relative capital cost of the 5000-kw machine producing 100,000 lb per hr of process steam from a waste heat boiler as compared to the installation cost of a high pressure boiler combined with an extraction turbine; the extraction turbine to produce 5000 kw when extracting 100,000 lb per hr of process steam and approximately 25,000 lb per hr condensing? The 100,000 lb per hr steam extracted should produce about 2500 kw at a 40-lb water rate and the 25,000 lb per hr condensed should produce about 2500 kw at a 10-lb water rate or a total of 5000 kw.

W. B. Wilson: That depends a lot on local conditions—the supply of cooling water, etc.; but roughly, based on the units that we have made a check on, I would expect the simple cycle combustion gas turbine plant with an exhaust-heat recovery boiler would cost approximately 80 per cent the cost of a steam turbine plant to provide the same plant requirements for electric power and process steam.

P. F. Kinyoun: The comparison is based on wanting 100,000 lb per hr of process steam and 5000 kw which can be produced with a gas turbine driven generator plus a waste heat boiler or by a high pressure boiler plus an extraction turbine.

W. B. Wilson: That would mean the exhaust-heat recovery boiler used with the combustion gas turbine would have to be equipped for supplementary fuel firing, which is a reasonable thing to do. As stated earlier I would expect cost of the combustion gas turbine to come somewhere in the neighborhood of 80 per cent of the steam plant. The gas turbine would operate at a power plant cycle efficiency of about 65 to 70 per cent when credited with heat recovered from the exhaust gases to generate process steam. The automatic-extraction-condensing steam turbine, passing a portion of its steam flow to the condenser to generate power might operate at 55 to 60 per cent plant efficiency. In other words, you are passing about 20 to 25 per cent of the boiler flow to the condenser to generate power, and that brings over-all power plant efficiency down. For the particular conditions which you outlined, initial cost of the simple cycle gas turbine power plant should be lower and the power plant efficiency higher than for a steam turbine plant. If the same type of fuel is used, the over-all fuel cost of the gas turbine plant would be lower.

1952 ANNUAL CONVENTION *and* IRON AND STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ENGINEERS

CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

***September* 30 *October* 1, 2, 3**

TO THE MEN OF THE STEEL INDUSTRY . . .

As steel production costs creep ever higher and higher, cost-cutting ideas become more and more important. The 1952 AISE Convention and Iron and Steel Exposition, larger than ever before, will abound with such ideas — in the exhibits of the exposition, in the papers of the technical sessions, and in conversations with men from other plants. Engineering, operating and maintenance men can obtain fresh viewpoints, new ideas and broadened perspective that will benefit them and their companies.

We are glad that we can invite men of the industry to participate in these opportunities. Plan to attend and to bring some of your co-workers. There is no registration fee, nor must you be an AISE member to attend.

I. N. TULL, President
AISE

Preview

IRON AND STEEL EXPOSITION
AISE
ANNUAL CONVENTION

▲ MORE than 10,000 persons are expected to attend the 1952 Iron and Steel Exposition, to be held concurrently with the Annual Convention of the Association of Iron and Steel Engineers in Cleveland Public Auditorium, September 30, October 1, 2 and 3.

For the 1952 Exposition, over 400 exhibit spaces have been reserved by over 200 firms, all of them concerned with some product or service of interest to the iron, steel and allied industries.

Technical sessions of the annual convention will be integrated so that those attending can take full advantage of both the exhibits and technical sessions. Open to everyone attending the Exposition, these sessions will be divided into separate morning and afternoon programs that permit those attending to hear a representative group of discussions on their preferred subjects (design, construction, engineering, operation and maintenance) and also view all of the exhibits.

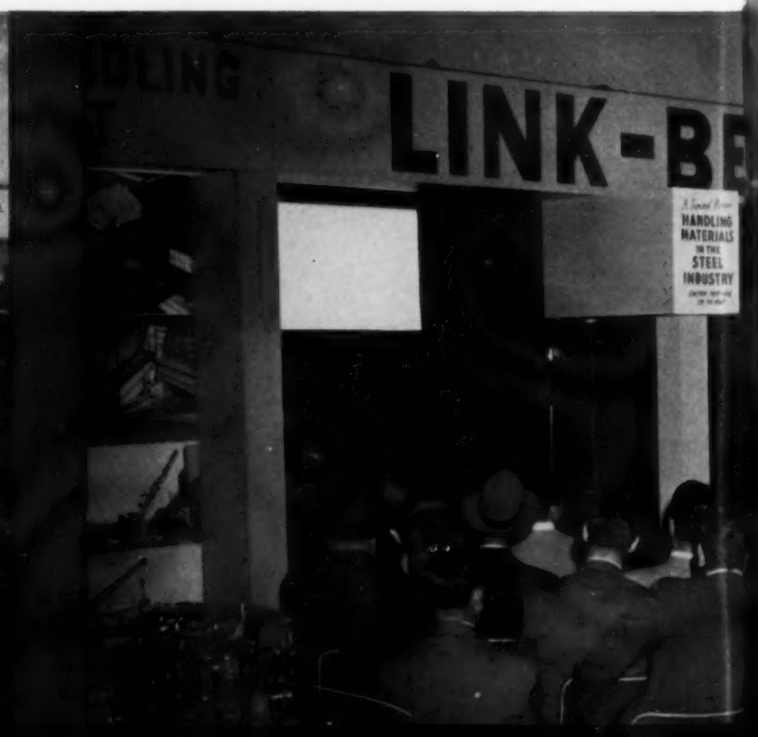
This type of scheduling affords firms within easy driving distance of Cleveland to arrange to send to each specific session the individuals most vitally concerned with the subjects to be discussed, thereby obtaining maximum benefit from the program without interfering with plant operation.

AISE technical sessions and the nearly 200 exhibits are geared to men in the plant as well as to top officials. The Iron and Steel Exposition is described as the only show for iron and steel producing industries aimed at presenting latest techniques and developments in every phase of iron and steel production and maintenance.

Tickets for the 1952 Iron and Steel Exposition will be widely distributed throughout the iron, steel and allied industries, and also may be obtained, upon request, from the Association of Iron and Steel Engineers, 1010 Empire Building, Pittsburgh 22, Pa. AISE membership is not required for attendance and there is no registration fee.

Cleveland, Ohio, is only a short driving distance from most steel mill centers in the eastern part of the United States.

Many exhibiting companies feature technical motion pictures made especially for steel industry supervisory personnel.



Technical meetings of the AISE are open to anyone identified with the iron and steel or allied industries. It is not necessary to be an AISE member to attend. Meetings are scheduled so as to give time to visit the Iron and Steel Exposition.

A trip through the Iron and Steel Exposition will promote many ideas of value to the individual and his plant.

An outstanding event of the AISE Convention will be the annual banquet which will be held in the Grand Ballroom of the Hotel Statler in Cleveland.

Three large halls in the Cleveland Public Auditorium will house over 400 booths of more than 200 exhibitors.

Program

1952 AISE CONVENTION and IRON AND STEEL EXPOSITION

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CLEVELAND PUBLIC AUDITORIUM
CLEVELAND, OHIO

Tuesday, September 30

9:00 am—REGISTRATION—Main Lobby

9:15 am—BUSINESS MEETING—Ball Room

Conducted by President I. N. Tull

9:30 am—ELECTRICAL SESSION—Ball Room

Chairmen: A. J. F. MacQueen, Electrical Superintendent, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada.
W. J. Tunny, Superintendent, Electrical Maintenance, Youngstown Sheet & Tube Co., East Chicago, Ind.

"Air Filters Applied to Cooling Systems of Electrical Rotating Equipment," by Fred C. Reutenauer, Design Engineer, Elliott Co., Ridgway, Pa.

"Transformer Oils for Modern Industry," by Andrew S. Morrow, Staff Engineer, Lubricants Department, Shell Oil Co., New York, N. Y.

"A Simplified Automatic Ingot Buggy," by I. N. Tull, Electrical Superintendent, Republic Steel Corp., Cleveland, Ohio, and Hugh S. Fegely, Control Engineer, Westinghouse Electric Corp., Buffalo, N. Y.

2:00 pm—MECHANICAL SESSION—Ball Room

Chairmen: J. A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.
F. E. Robinson, Assistant Division Engineer, American Steel and Wire Division, United States Steel Co., Cleveland, Ohio.

"Chromium Plating as Used in the Iron and Steel Mills," by John B. Allen and Jerome D. Tulloch, Chromium Corp. of America, Chicago, Ill.

"Material Maintenance Program," by J. B. Whitlock, General Maintenance Engineer, and J. E. Anderson, Research Engineer, Armco Steel Corp., Middletown, Ohio.

"New Developments in Submerged Melt Welding for Steel Mill Maintenance," by D. E. Knight, Development Engineer, Linde Air Products Co., Newark, N. J.

2:00 pm—COMBUSTION SESSION—Club Room B

Chairmen: E T. W. Bailey, Chief Combustion Engineer, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.
R. A. Lambert, Superintendent, Steam and Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"A New High Temperature Alloy," by M. N. Ornitz, Works Manager, and R. H. English, Chief Metallurgist, National Alloy Steel Division of Blaw-Knox Co., Blawnox, Pa.

"Experiences with Oxygen Control in Open Hearth Flue Gases," by F. P. Hubbell, Superintendent Fuel Department, Homestead Works, United States Steel Co., Munhall, Pa.

"Application of Automatic Combustion Controls to A New Open Hearth Shop," by F. S. Swaney, Combustion Engineer, Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

10:00 pm—President's Dance—Euclid Ball Room, Hotel Statler

Wednesday, October 1

9:00 am—ELECTRICAL SESSION—Ball Room

Chairmen: Eric L. Anderson, Superintendent Electrical Department, Bethlehem Steel Co., Johnstown, Pa.
F. H. Wickline, Electrical Engineer, National Tube Divison, United States Steel Co., Pittsburgh, Pa.

"The Magnetic Amplifier and its Application in the Steel Industry," by W. E. Miller, Manager, Steel Mill Section, Industrial Engineering Department, General Electric Co., Schenectady, N. Y.

"The Meaning of Commutator Film," by Leon D. Cook, Supervisor Substations, Commonwealth Edison Co., Chicago, Ill.

"Synchronous Motor Torque Requirements for Steel Mill Applications," by Dr. William A. Thomas, Electrical Engineering Manager, The Electric Products Co., Cleveland, Ohio.

9:00 am—COMBUSTION SESSION—Club Room B

Chairmen: A. F. Kritscher, Development Engineer, National Tube Div., United States Steel Co., Pittsburgh, Pa.
G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.

"Wide Range Metering of Oxygen in Steel Plants," by M. S. Gare, Manager, Ring Balance Division, Hagan Corp., Pittsburgh, Pa.

"Continuous Process Produces High Strength Oil Well Casing by Quenching and Tempering Carbon Steel," by F. H. Bremmer, Chief Combustion Engineer, and F. J. Zehnder, Project Engineer, Spang-Chalfant, Division of The National Supply Co., Ambridge, Pa.

"Castable Refractories in the Steel Mill," by J. D. McCullough, Chief Engineer, Refractories Division, The Babcock & Wilcox Co., New York, N. Y.

2:00 pm—BLAST FURNACE SESSION—Ball Room

Chairmen: C. G. Hogberg, Assistant to Chairman, Blast Furnace Committee, United States Steel Co. of Delaware, Pittsburgh, Pa.
W. H. Collison, Assistant General Superintendent, Furnace Division, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

"Injection of Natural Gas and Oxygen into the Blast Furnace," by Dr. Julien O. Raick, Ingenieur Civil des Mines A. I. Lg. Brussels, Belgium, and James E. Brassert, Vice President, H. A. Brassert & Co., Inc., New York, N. Y.

"Exploration and Development of a New Iron Mine," by R. P. Bremner, Assistant to Vice President Charge of Operations, Youngstown Sheet & Tube Co., Youngstown, Ohio.

"Material Handling Layout of Blast Furnace and Coke Plant at Fairless Works," by Carleton Lord, Materials Handling Engineer, United States Steel Co., Pittsburgh, Pa.

2:00 pm—LUBRICATION SESSION—Club Room B

Chairmen: Robert A. Kraus, Assistant Maintenance Superintendent, Republic Steel Corp., Chicago, Ill.
N. I. Whiteley, Lubrication Engineer, American Steel & Wire Division, United States Steel Co., Cleveland, Ohio.

"Lubricants for Drawing Metals," by Allen A. Brown, Reilly-Whiteman-Walton Co., Conshohocken, Pa.

"The Functioning of a Lubrication Organization in Heavy Rolling Mills," by Robert R. Taylor, Division Engineer, Maintenance and Lubrication, United States Steel Co., Gary, Ind.

"Replacements for Palm Oil in Cold Rolling Steel," by Robert C. Williams, Director of Research, The Ironsides Co., Columbus, Ohio.

6:00 pm—OLD TIMERS DINNER—Euclid Ball Room—Hotel Statler

Thursday, October 2

9:00 am—OPERATING PRACTICE SESSION—Ball Room

Chairmen: Emil Kern, Vice President in Charge of Engineering, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
F. M. Darner, Chief Engineer, Manufacturing Division, Republic Steel Corp., Cleveland, Ohio.

"Processing Properties and Applications for Cold Finished Steel Bars," by J. F. Byers, Metallurgist Bar Products, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"The Extrusion of Steel, Equipment, Operation, and Production," by Jacques Sejournet, General Manager, Comptoir Industriel D'Etirage Et Profilage De Metaux, Paris, France.

"A Machine to Cold Reduce 18-in. Tubing," by Graham B. Brown, Administrative Assistant, Tube Reducing Corp., Wallington, N. J.

9:00 am—LUBRICATION SESSION—Club Room B

Chairmen: D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.
Charles A. Bailey, Lubrication Engineer, National Tube Division, United States Steel Co., Pittsburgh, Pa.

"Oil Mist Lubrication for Industrial Machinery," by E. Ralph Harris, Alemite Division, Stewart-Warner Corp., Chicago, Ill.

"The Effect of the Lubricant on Gear Performance," by V. N. Borsoff, Research Engineer, and S. S. Sorem, Research Engineer, Shell Development Co., Emeryville, Calif.

"Considerations in the Design of Plain Bearings," by A. E. Cichelli, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

7:00 pm—FORMAL DINNER AND DANCE—Grand Ball Room—Hotel Statler

Friday, October 3

9:00 am—OPERATING PRACTICE SESSION—Ball Room

Chairmen: T. M. Fairchild, Assistant to the General Manager, Bethlehem Steel Co., Johnstown, Pa.
Paul E. Thomas, Assistant to General Superintendent, United States Steel Co., Gary, Ind.

"Applications of the Radiation Gauging Method in the Steel Industry," by George B. Foster, Technical Director, Industrial Nucleonics Corp., Columbus, Ohio.

"The Recovery of Tin from Scrap Tinplate," by A. J. Krombholz, Assistant Head, Chemical Development and Research Division, Weirton Steel Co., Weirton, West Va.

"Dynamic Painting in Steel Plants," by Joseph K. Seyler, Superintendent, Hazelwood Cold Finishing Department, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

9:00 am—ROLLING MILL SESSION—Club Room B

Chairmen: D. W. Lloyd, General Superintendent, Youngstown Sheet & Tube Co., Youngstown, Ohio.
George L. Pimlott, Assistant Superintendent of Bar Mills, Republic Steel Corp., Cleveland, Ohio

"Mechanized Hot Scarfing," by J. H. Zimmerman, Manager, Development and Process Service, Linde Air Products Co., New York, N. Y.

"Aluminum Foil and Its Uses," by W. B. Hackett, Assistant to President in Charge Engineering, Lewis Foundry and Machine Division, Blaw-Knox Co., Groveton, Pa.

"High Speed Mills and Their Application to Ferrous and Non-ferrous Rolling," by George Perrault, Jr., E. W. Bliss Co., Salem, Ohio.

2:00 pm—ELECTRICAL SESSION—Ball Room

Chairmen: K. L. Johannsen, Assistant Division Superintendent, Maintenance and Utilities, United States Steel Co., Fairless Works, Morrisville, Pa.
L. V. Black, Superintendent, Electrical Department, Bethlehem Steel Co., Bethlehem, Pa.

"The Adjustable Voltage Ore Bridge Drive at Otis Works," by Clark B. Risler, Industry Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., and E. C. Juhnke, Electrical Engineer, Otis Works, Jones & Laughlin Steel Corp., Cleveland, Ohio.

"Modern Lighting Systems for Steel Mills," by R. F. VandenBoom, Illuminating Engineer, General Electric Co., Cleveland, Ohio, and D. L. Beeman, Manager, Industrial Power Engineering, Industrial Engineering Department, General Electric Co., Schenectady, N. Y.

"Protection of Underground Cable Sheaths," by T. W. Alexander, Jr., Transmission Engineer, The Bell Telephone Co. of Pennsylvania, Pittsburgh, Pa.

2:00 pm—COMBUSTION SESSION—Club Room B

Chairmen: F. Bruce Bevelheimer, Power and Fuel Engineer, Steel Division, Ford Motor Co., Dearborn, Mich.
George H. Krapf, Chairman, Fuel and Power Committees, United States Steel Co., Pittsburgh, Pa.

"Safe Handling of Fuels, Hazardous Gases and Liquids," by F. R. Pullen, Fuel Engineer, Bethlehem Steel Co., Johnstown, Pa.

"The Characteristics of Fuel Oils Used in the Steel Industry," by John P. Critchlow, Chief Fuels and Lubricants Engineer, Rolling Mill Section, Gulf Oil Corp., Pittsburgh, Pa.

"The Pumping and Burning of Tar and Pitch," by Warren A. Pond, Manager of Industrial Viscous Fluid Department, Fluid Systems, Inc., New Haven, Conn.

EXPOSITION AND TECHNICIAL SESSIONS are at Cleveland Public Auditorium.
SOCIAL FUNCTIONS are at Hotel Statler.

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Iron and Steel Exposition Hours

September 30 — Tuesday,	10:00 am - 10:00 pm
October 1 — Wednesday,	10:00 am - 10:00 pm
October 2 — Thursday,	10:00 am - 5:30 pm
October 3 — Friday,	10:00 am - 4:00 pm

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NO REGISTRATION FEE

Ladies Program

HEADQUARTERS

PARLOR E

HOTEL STATLER

TUESDAY, September 30

9:00 am — Ladies Registration — Parlor E, Hotel Statler

12:00 noon — Luncheon — Euclid Ball Room, Hotel Statler

Music — Entertainment — Door Prizes

10:00 pm — President's Dance — Euclid Ball Room, Hotel Statler

WEDNESDAY, October 1

12:30 pm — Luncheon — Westwood Country Club

Buses to leave Hotel Statler 11:30 am (Ladies meet in Parlor E, Hotel Statler)

THURSDAY, October 2

7:00 pm — Formal Dinner and Dance — Grand Ball Room, Hotel Statler

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Honorary Chairwoman—Mrs. I. N. Tull *General Chairwoman*—Mrs. Clifford W. McAllister

Vice Chairwoman—Mrs. Walter V. Magee

★

To partially cover costs of ladies activities, a flat charge of $3.00 will be made for the luncheons on Tuesday and Wednesday. This must be paid on registering, when tickets will be issued for these events.

Hotel Reservations

Arrangements have been made with Hotels Statler, Cleveland and Hollenden whereby they have set aside blocks of rooms for the use of those attending the convention and exposition of the Association of Iron and Steel Engineers in Cleveland, Ohio, September 30, October 1, 2, and 3, 1952.

We suggest that you make your reservation as early as possible, directly to the hotel of your choice. If that hotel cannot take care of you, they will pass your reservation on to the Cleveland Convention Bureau, who will place you elsewhere.

Be sure to state specifically the type of accommodations desired and the time of your arrival.

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CLEVELAND

September 30, October 1, 2, 3

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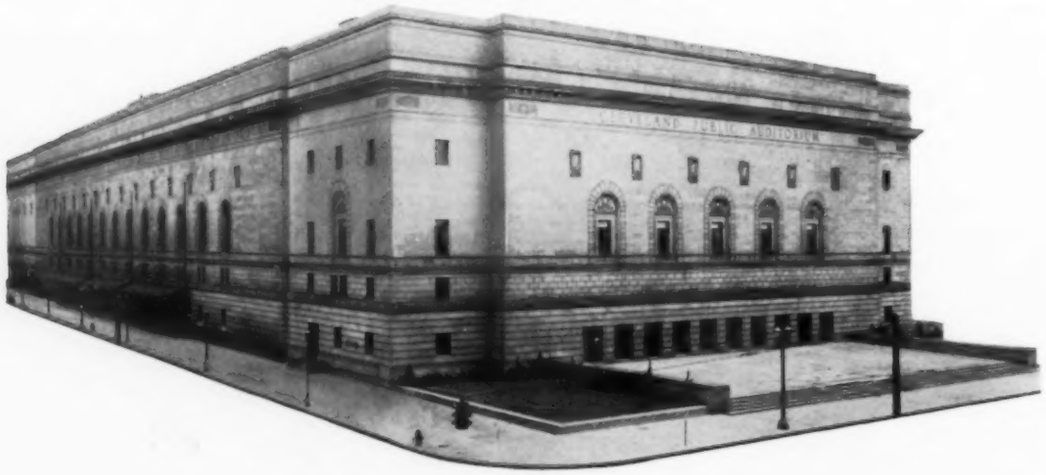

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. . . . in reviewing problems of iron and steel production, leading operators of the steel industry, at the sixtieth general meeting of the American Iron and Steel Institute held in New York City on May 21 and 22, 1952, presented a number of interesting papers . . . . special panels were held on processing, research, open hearth and industrial relations . . . . because of their value to the industry, some of the papers are abstracted here . . . .

"CHANGES IN THE PROCESSES AND PRODUCTS OF THE TIN PLATE INDUSTRY"

By CHARLES A. FERGUSON, General Superintendent
Gary Sheet and Tin Mill
United States Steel Co.
Pittsburgh, Pa.

▲ ALTHOUGH there is some reference to coating iron with tin in the first Christian century, the most authentic writings relate that, following the discovery of tin in Bohemia about 1240 A.D., the tin plating of iron sheets was practiced in that country for several centuries. Tin was found in Saxony in 1458, but it was not until 1620 that it was applied there as a coating for sheets.

Tin plate was first made in England in 1665-1670 but there was very little production until 1706. At that time, a substantial tariff was imposed as a protection to British manufacturers. Hand hammered iron plates were dipped manually in molten tin. About 1730 the idea of processing iron sheets through rolls driven by water power became a reality. The superior quality of this product was immediately recognized and furnished the basis for widespread advances in England and Wales during the next 100 years.

From the most authentic records, it is reported that the first actual tin plate in America was produced in Pittsburgh in 1858-1859. From 1872 through 1874, rolling mills and tinning equipment were built and operated at Leechburg, Pa., Demmler, Pa., and Wellsville, Ohio. These were inefficient operations and they could not compete with the more experienced producing of tin plate in Wales. As a result, the plans were shut down very soon after they had started. In 1879 and 1880 these mills again resumed operations, but almost immediately discontinued manufacturing tin plate. Their efforts, in the next decade, were devoted to processing tin mill black plate, which was used for show cards, tea trays and stamped ware.

The tin plate industry in the United States, as we know it today, had its beginning in 1892. As previously mentioned, low import tariffs and prices of tin plate from Wales, prior to this time, had hampered its manufacture in this country, but economic and political changes, including a protective tariff in 1891, opened the way for vast expansion. Pennsylvania and Ohio, with a supply of steel and fuel, and Indiana and Illinois with natural gas, were particularly attractive for tin plate manufacture. The immense fertile food-growing areas of the midwest contributed, also, to the desirability of locating mills where there was going to be a sure demand for tin plate for cans. The first complete tin mill was constructed in 1891-1892 at Elwood, Ind., by the American Tin Plate Co. Consequently, much of the early history of the industry in our country centered around this plant.

In 1926, Columbia Steel Co., now Armco, erected at Butler, Pa., a mill that would make 36-in. wide strip. This installation, used chiefly for sheet requirements, comprised a two-high universal roughing stand with 4 four-high finishing stands, followed by run-out tables and coilers. Strip as light as 0.058 in. thick was produced.

The first application of hot rolled strip in tin plate production was accomplished in 1927 at Gary Tin Mill of the American Sheet and Tin Plate Co. This new unit was continuous from the slab reheating furnaces through the roughing and finishing stands, and was designed to roll strip 26 in. in maximum width and approximately 180 ft in length. The strip was cut into lengths, matched together, doubled into packs and finished to tin plate thicknesses on conventional hand hot mills. This materially reduced the cost of producing tin plate and promoted better quality characteristics. In 1934 the mill was rebuilt and widened to roll 36-in. maximum width strip for conversion into cold reduced plate.

The early installations of hot strip mills consisted of two or more recuperative, pusher type slab heating furnaces; one or more roughing mills in which the slab was rolled through one mill at a time; and a holding table, followed by four or more finishing mills through which the strip was rolled simultaneously. As the strip emerged from the last stand, it was delivered over a run-out table to coilers or pilers. These early mills were designed to have a top delivery speed of 1000 feet per minute and to roll about 100 to 125 tons per hour.

As a good example of progress in hot strip manufacture, we are mentioning the results of the modernization recently completed on the 80-in. mill at Gary Sheet and Tin Mill of United States Steel Co. Since heating capacity has restricted production on practically every type of rolling mill that was ever built, this program included five slab heating furnaces with a total heating capacity of 500 tons per hour and equipped to burn oil, natural or coke oven gas. The mill has a top delivery speed of 2300 fpm and is equipped with three coilers. Currently, the unit is producing at a rate of 350 to 400 tons per hour on carbon steel and 105 tons per hour when rolling stainless.

Figure 1 — A typical modern 4-stand tandem mill is here shown.

As hot strip mills increased in capacity and speed, the refinement of electrical controls was a major problem. Successful operation required the regulation of the speeds on a multiplicity of mill stands since the strip passed through all of them at the same time. Likewise, the development of rolls and bearings for high speed heavy duty work was a continuing effort. Coiling of the strip at high speeds and at relatively high temperatures involved extended concentrated study by equipment makers and mill engineers. Of equal importance was the operating "know how" which had to be established by trial-and-error methods, together with a determination and resolution to make the equipment function successfully.

The modern hot strip mill is constructed for mass production and every roll, control, bearing, guide, spray, and even the bolts and nuts must be maintained perfectly to insure maximum output. Local operating controls are on the mill floor but the main station of the operation as a whole is centered in a pulpit overlooking the entire roll train. Optical and radiation pyrometers, electric eyes, width and X-ray thickness gages, supplemented by an adequate quantity of high pressure steam and water, furnish valuable assistance to the operators in bringing the strip through the mill and into the coilers at desired temperatures, width and thickness.

PICKLING

In the early production of tin plate the scale was removed from the sheets by laborious hand rubbing with sandstone. In later years the sheets were immersed for several days in solutions made by fermenting rye and barley. Vinegar, beer and wine were also employed as pickling agents; the process being accelerated by heat from charcoal stoves, after which the sheets were washed in water and sand.

The continuous pickler for handling hot rolled strip, had its beginning in 1913, when a machine was developed to process narrow widths. As mills were built to produce wider coils, wider continuous strip pickling units were adopted. About 1923, advances in design of uncoiling and recoiling equipment gave the art of continuous pickling a real commercial aspect.

By 1926, the Wheeling Steel Corp. had built a pickler for maximum strip widths of 30 in. From this time on, developments were rapid and included better devices for uncoiling, breaking the surface scale, joining of coils and other improvements. A stitching method was used initially for joining coils, but lap joints could not be cold reduced. As a result, butt welding and planing and trimming of the weld proved to be the answer to that problem for the heavier gages. With these and many other developments and refinements, including side trimming and oiling, the present-day continuous pickler operates at a speed as high as 600 fpm and in an 8-hr turn will produce, in tin plate widths, over 500 tons of pickled strip ready for cold reduction.

COLD REDUCTION

In the last operation of hot pack rolling the sheets were heated and rolled to a predetermined length which resulted in the correct thickness for the individual

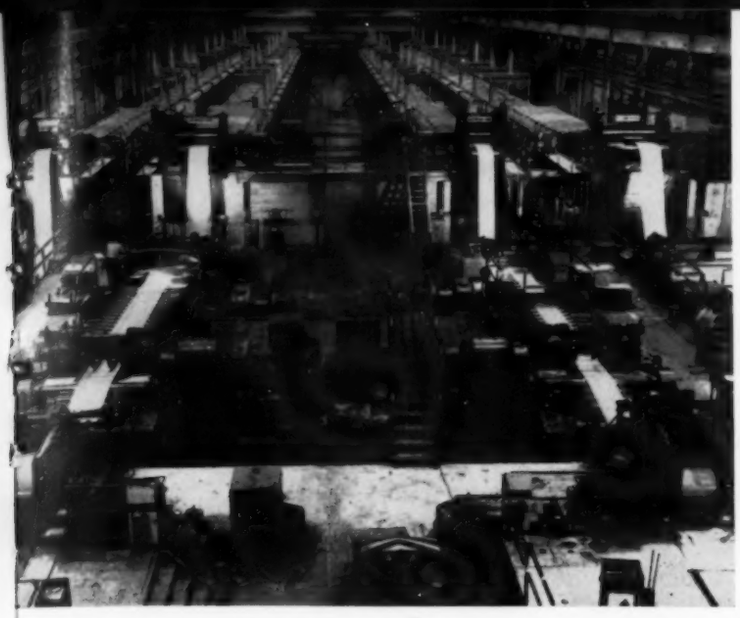

Figure 2 — Delivery end of modern 4-unit continuous pickling department.

sheets in the pack. The cold reduction of hot rolled pickled strip, which is accomplished by a combination of cold rolling and stretching, is a comparable operation in that the material is thereby reduced to its final gage.

The introduction, in 1929, of the cold reduction process for tin mill widths and gages had as important an effect on the industry as did the change to rolled sheets from hammered sheets 200 years before. The new process proved to be equally as valuable to the can manufacturers and to the food packers as it was to the tin plate producers, because cold reduction brought with it the ability to utilize lower metalloid steels than could be used on hand mill product. This meant better ductility to meet more severe fabricating requirements and most of all, it meant better finished surface and greater corrosion resistance in the packing of many products.

The first tandem four-high cold reduction mill, designed to produce tin mill products, was the four-stand mill constructed in 1929, at the Yorkville, Ohio, plant of Wheeling Steel Corp. In 1933, Gary Sheet and Tin Mill, American Sheet and Tin Plate Co., Gary, Ind., placed in operation the first single stand four-high reversing mill for tin plate.

Single stand mills, as opposed to tandem type, had minor advantages of compactness, initial cost, and better flexibility for producing small quantity items of odd widths and gages. However, tandem mills were the logical arrangement, and very shortly, five-stand, four-high tandem mills became standard equipment for tin mill products. Operating speeds of these units have increased by leaps and bounds. Initially, 1100 fpm out of No. 5 stand was considered good, but a recent installation has a delivery speed up to 6000 fpm, and a mill now under construction is designed for a maximum of 7000 fpm.

Efficient lubrication of the strip as it passes through the rolls is vital at these high speeds. Likewise, it is equally important, if proper roll shapes are to be maintained, that the heat developed during cold reduction be absorbed by a coolant. The lubricants are either vegetable or mineral oils while the cooling medium is water. Numerous systems are used to apply the lubricant and coolant separately or in combination such as an emulsion. Lubricants which are stable under the high rolling pressures are the most satisfactory. Many schemes for recovering and re-using the materials have been developed for economy purposes.

Lubricant clinging to the strip after cold reduction is generally removed prior to annealing. This is necessary for good tinning and for proper adhesion of lacquers, which are frequently applied to the untinned product. The removal of the rolling lubricant and any other foreign matter from the surface involves passing the strip through tanks of a hot alkaline solution, followed by rinsing, drying and recoiling under controlled tension to avoid subsequent telescoping or collapsing. Tension control in recoiling is also important if "sticking" of the coil product during batch annealing is to be minimized. In many instances electrolytic action has been added to the lines to obtain more effective cleaning at higher operating speeds.

ANNEALING

Plate rolled by the hot pack process was generally annealed twice. One annealing followed hot rolling and pickling, while the second followed the cold rolling operation. Strip produced by the cold reduction method requires only one annealing.

Early commercial annealing was done in batch "in and out" furnaces. The pickled sheets were piled on a suitable cast iron or steel stand and covered by a cast iron or steel box. The charge was pushed manually, on large cast steel balls, into the furnace. Various mechanical devices were introduced later to eliminate the manual parts of the operation. The charge was brought up to required temperature with coal or gas firing and was then removed from the furnace and allowed to cool to room temperature. A sand seal between stand and cover minimized oxidation of plate during firing and cooling. The temperature was judged by visual observation through a peep hole in the furnace door. The first attempt to control the temperature scientifically was by the placement of a pyrometer in the furnace roof. This was helpful means of estimating the temperature of the charge and led eventually to the application of thermocouples in each charge, which more accurately controlled this heat treatment.

Many furnace designs were used for batch annealing. The tunnel type, commonly known as the Dressler muffle furnace, was the first approach to continuous annealing. The tunnel, about 300 feet long, was equipped with a suitable railway and cars for conveying the charges. When in full operation, an entering car forced a car out at the exit end, thus making a continuous operation. The maximum temperature was reached at the middle of the furnace, after which the charge entered the cooling zone. The furnace was of a recuperative type in that the heat from the cooling charges was transmitted by ducts to the heating zone, thus adding some to the efficiency of this furnace.

High fuel and maintenance costs left much to be desired in any of the furnaces of these types. As a result, there was considerable enthusiasm, about 1930, when the portable, radiant tube furnace came into use. This development included fabricated steel, brick lined bases, and steel stools on which the coils were charged

Figure 3 — One of the later developments is the continuous annealing furnace for tinplate.

for annealing. Steel inner covers, either cylindrical for each tier of coils, or rectangular to embrace the entire charge, were employed with sand seals. In some installations motor driven fans were placed in the stools to circulate the controlled atmosphere under the covers and thereby shorten the time of the cycle and improve uniformity of temperature. One fabricated steel, brick lined, portable heating unit equipped with horizontal or vertical alloy radiant tubes serviced at least three bases. Definite improvement in annealing rate and fuel economy resulted. A further gain was attained later in some installations by eliminating the expensive alloy tubes and burning the gas openly inside the unit.

Perhaps no part of the tin plate manufacturing process has caused more trouble than annealing. With pack rolled sheets, fear of stickers prevented heating to a temperature which would make them consistently as soft as desired. Regardless of all precautions, sticking was not eliminated and many times caused minute holes to be pulled in the sheets when they were separated for cold rolling. Potassium chromate dips were employed by some producers in connection with the pickling, prior to annealing, in order to provide a surface film that would minimize sticking and permit higher temperatures with more uniform softness, but this by no means solved the problem. The introduction of cold reduced material in coils did not do away with stickers entirely, but in general some of the troublesome features of pack rolled sheet annealing were eliminated and at the same time a more uniform, dependable and ductile product came into being.

Just a few years after the introduction of cold reduction in tin plate gages and widths, Crown Cork and Seal Co. installed, at Baltimore, a tower type continuous annealing furnace that would heat treat cold reduced strip under controlled atmosphere at a maximum speed of 300 fpm. Ten years later, Dominion Foundries and Steel Co., Ltd., Hamilton, Ontario, put in a duplicate of Crown Cork and Seal's furnace and incorporated an alkaline cleaning process ahead of the annealing.

This combination of the two operations and the unit itself created considerable interest. In 1949, Inland Steel Co., Indiana Harbor, Ind., started production on a unit designed to clean and anneal continuously at a maximum speed of 1000 fpm. Last year, Gary Sheet and Tin Mill of United States Steel Co., Gary, Ind., completed installation of a 1000 fpm continuous annealing line incorporating electrolytic cleaning as part of the operation. Construction is under way on a similar unit at the Fairless works of United States Steel Co. at Morrisville, Pa.

Continuously annealed plate possesses uniform physical properties of the type that make it adaptable for a wide range of can making applications. The can manufacturer is pleased with the possibility of smaller and more flexible inventories and can see advantage in quicker emergency deliveries of plate, since continuous annealing eliminates the long batch coil annealing cycle. The tin plate producer visualizes satisfying the trade with a reduction in the number of steel grades, along with generally better all around mill processing performance. All in all, it would appear that continuous annealing is not only here to stay, but to expand.

TEMPER ROLLING

The term "temper rolling" came into being along with cold reduced processing but we are including the analogous cold rolling of pack rolled plate under this heading in order to highlight the contrast between the treatments. In the pack rolled process the finishing operations after annealing, and preliminary to coating, consisted of cold rolling followed by annealing at a low temperature. Cold rolls were usually three stands of two-high mills in tandem connected by belt conveyors. The sheets were manually fed to the first stand and were packed by hand on annealing stands at the exit end of the roll train. The irregular and variable shape of the sheets after annealing and opening defeated the application of any mechanical device for feeding into cold rolls, but mechanical packers, after cold rolling, were developed and used to advantage in many plants.

The attainment of the desired surface and flatness by cold rolling of pack rolled sheets usually resulted in a springiness that had to be relieved by a final, low temperature (1000 F), "white" annealing. On the other hand, with cold reduced product, control of annealing after cold reduction and control of the temper rolling extensions after the annealing provide proper end product characteristics, so that no final "white" annealing is necessary.

Temper rolling of cold reduced, annealed coils requires heavy four-high mills, usually two stands in tandem with electric generator drag type uncoilers at the entry end, tension rolls between the mill stands and

the reel at the exit end. The rough finish imparted to the strip by the shot blasted work rolls in the first stand, to meet temper requirements, is eliminated by the bright finish work rolls in the second stand. For the majority of tinned products, both hot dipped and electrolytic, this bright surface is standard, although it is possible to make various surface textures by varying the work roll finishes.

The introduction of cold reduced plate, which included the ability to utilize steel of any desired composition, also brought with it the classification of product into six different tempers. These cover six hardness ranges with aims overlapping; No. 1 being very soft and No. 6 being very stiff. This progress in satisfying customer requirements in comparison with the old pack rolled days could not have been attained without the help of the modern temper mill, although steel composition and manner of annealing still are vital factors in the end results.

In 1942, the Republic Steel Corp. installed a unique unit called a unitemper mill, but better known in the industry as a cold stretch mill. This unit consists of 2 two-high mills, one vertically above another, in the same housing. Because of the short distance between the rolls and the wrap of the strip around them, most of the work is done by stretching rather than by rolling. This mill operates up to 4100 fpm.

The temper mill is a precision finishing machine, handling dead-soft strip, and requires the most accurate control of tension at the uncoiler end reel and between stands to insure production of a strip with the proper hardness, surface and flatness necessary for the fabrication of the various products made from tin plate.

Pack rolled sheets were cut to size directly after hot rolling and went on through processing and shipment without further shearing. Cold reduced product, after temper rolling, is subject to variations in practice. One producer will send the temper rolled coil directly to the electroplating line, where it will be side trimmed, and after tinning, will be recoiled and then crosscut into sheets as a separate operation. Another producer will side trim first and re-coil, after temper rolling, and then in the electrotinning line will crosscut into sheets after coating. Coils for hot dip tinning and for uncoated black plate orders normally are processed, after temper rolling, through lines that include rotary side trimming and flying shear crosscutting in one operation.

COATING STEEL WITH TIN

The first patent covering the introduction of rolls in the tin bath was obtained by Moorewood & Rogers in 1843. This was a decided advance in the method of tinning, although it remained necessary to push the plates through the molten tin into the nip of the rolls with an iron tinning fork and catch them by hand with a pair of tongs as they emerged from the exit end. The tinned sheets were then deposited in a rack for cooling and finally cleaned and polished with wheat middlings and hand-manipulated sheep skin buffers. About this same time the grease pot, mentioned above, was replaced by zinc chloride fluxing, which remains as a vital part of the hot dip tinning operation of today.

The year 1915 saw the start of a general trend to completely mechanize the hand-feeding process. Continued experimentation resulted in the commercial application of mechanical feeding equipment about 1922. This Davis, or roll type feeder, basically just a sequence of rolls submerged in the molten tin and designed to convey the sheets to the tinning machine, located at the exit side of the tin pot, doubled output. About this same time, the magnetic or Poole feeder, located ahead of and in tandem with the Davis feeder, was perfected and pronounced a success. This equipment had a series of permanently magnetized rolls above and below the water line in the feeder bosh. Magnetic adherence of the sheets to these driven rolls conveyed the sheets out of the bosh into the roll feeder. As these mechanical changes were accepted by the industry, it became possible for one man to keep the Poole feeders of two tinning pots supplied with plate for coating.

The eight-roll, duplex type coating machine, which had been commonly used for quite a few years, consisted of two passes, one behind the other, in the same pot. In order to accommodate the mechanical feeder this machine was completely redesigned and rebuilt, using one pass line only. The new machine, which is now universally in use, has three pairs of rolls arranged one above the other, that carry the sheets out of the molten metal and through the hot palm oil to the catcher.

In the early 1930's, an attempt was made to do away with the separate operation of pickling the sheets prior to tinning. A tank was installed in line with the tin pot and by a system of rolls and conveyor chains the sheet was conducted through an acid bath into the magnetic Poole feeder. The pickling tank was necessarily very long in order to get a clean sheet. Furthermore, it occupied a large area of floor space. When the speed was reduced to permit good pickling practice, the tin pot speed was too slow for economical operation and, consequently, the experiment was abandoned. Electrolytic pickling revived this idea. By means of a mechanical feeder, sheets are fed into the electrolytic pickling bath directly from the piles as they are received from the flying shear lines. Sheets from the pickler go directly to the feeder and then into the coating pot. In this way, the white pickling, an operation which involves heavy manual work and which results in appreciable handling damage to the product, is eliminated. This practice, now standard in modern tin house operation, has helped to increase output to 4000 lb per hour.

Cleaning after tinning has always presented many problems. Hand methods were used until 1861, at which time a machine for automatically rubbing the plates with an absorbent material, such as bran, to remove excess oil or grease, was adopted. Out of this development came the branner as we know it today. It consists of a series of two-high cloth rolls driven at differential speeds. An important part of the cleaning operation is the absorbent which circulates through the branner in contact with the plate and the cleaning rolls. Numerous materials have been tried, but cereal products such as wheat and rye bran or middlings have been most successful. During the First World War, because of scarcity, many substitutes, such as dried sawdust, wood flours, peanut hull meal and certain kinds of clay or marl were utilized with varying degrees of success.

The higher speed of operation of the tin pots and the resultant increased output was placing an intolerable

burden on the existent method of cleaning the plate. The orthodox branner could not perform its functions satisfactorily at the new rate. To remedy the difficulty and bring the entire operation into balance, research in cleaning was undertaken by the American Sheet and Tin Plate Co. at its New Castle works in 1924. Among the expedients projected, emulsification of the excess oil on the tin plate emerging from the tinning machine showed the most promise. This was rank heresy from the standpoint of the existent art, for even a few drops of water in the cleaning machine had been considered ruinous. Nevertheless, the new method, employing a weak aqueous solution of soda ash, worked effectively, and all of the headaches from the excessive use of middlings in the branner or cleaning machine disappeared. Further experimentation proved that washing by emulsification, followed by a finishing pass through the branner, in order that the plate might have a desirable very thin protective film of palm oil, solved the problem on a practical basis. This latter phase of the project was perfected at the Farrell works during 1924-1925, and the wet cleaning of tin plate became a standard operation.

From the start of the coating of tin plate mechanically, the hot dipped process has involved the passing of two or three sheets simultaneously, side by side, through the coating operation, then turning the direction of travel at right angles and putting the plates singly through the subsequent cleaning. In 1929, the American Sheet and Tin Plate Co. built a new tin house which included a decided departure from past practices.

Figure 4 — Electrolytic tinning line has speeded up production and conserved strategic tin.

All operations were in a straight line, which permitted the plates to go through the cleaning equipment side by side at a slower speed. Most new tin houses, built since that time, are the "straight through" type.

In the operation of the hot dip tin pots it never has been possible to produce a commercial product with a coating much below 1.25 lb per base box pot yield. Even at this coating weight level, strictly uniform tin distribution is impossible. In 1937, after long research and experimentation on laboratory and pilot plant scale, there was installed at Gary Sheet and Tin Mill of United States Steel Co. an electrolytic tinning line that proved to be the first successful unit for commercial production of electrotinned plate. This line was not built to replace hot dipped tin plate, but to produce an entirely new product which would meet all requirements for packaging such commodities as dry foods, paints, coffee, tea and like materials that did not present a corrosion hazard when packed. The installation first operated at a lineal speed of 150 fpm and produced an unmelted, brushed finish, with tin coating of 0.50 lb per base box. This constituted a saving of approximately one pound of tin per base box over standard hot dipped plate. As originally intended, the early electrolytic tin plate was used for dry product containers where corrosion resistance was not a major factor.

The seizure of the Far East tin sources by Japan in 1942 brought strict Government controls over the use of this metal. The electrolytic process fitted into this situation admirably and the demand for this new product resulted in immediate construction of many electrolytic tinning lines throughout the industry. These new units were of three types; commonly spoken of as phenol sulphonic acid, halogen and alkaline, depending upon the type of plating solutions used. All, however, were designed to produce a standard product of 0.50 lb per base box coating weight. As the application extended into new fields, it was soon apparent that certain qualities were lacking. Tremendous development programs were instituted with remarkable success. Melting of the electroplated tin coating, chemical treatments and oiling process were instrumental in improving appearance, corrosion resistance, solderability and enamel adhesion. All of these refinements soon became integral parts of the complete process.

The type of electrolyte employed, along with the naturally different ideas of engineers and operators, has led to wide variations in the installations of the many producers of electrolytic tin plate. Some prefer to incorporate all the parts of the operation into a single unit, while others choose to divide the sequence of processing into two or more separate, independent units. The actual plating of the tin coating can be done at exceedingly high speeds, although the first cost of the electrical equipment must be considered. If the strip is flying-shear cut into sheets in the plating line, then the shearing operation and not the plating will determine the maximum line speed. The numerous and varied layouts make comparisons of operating efficiencies between different producers a difficult matter.

As attempts were made to take full advantage of electrolytic tin plate, it became apparent that coating weights heavier than 0.50 lb would be required for certain types of food packs, while the requirements of other packs could be met with lighter coating weights such as

0.25 lb per base box. To satisfy the demands for these coating weights, Gary Sheet and Tin Mill has installed a new 0.25 lb line and has modernized an existing 0.50 lb line for more economical production of coatings heavier than 0.50 lb.

The recently built 0.25 lb line at Gary Sheet and Tin Mill includes electrolytic alkaline cleaning, electrolytic pickling, phenol sulphonic acid plating bath, melting unit, chemical treatment, oiler, flying shear and pilers in tandem. The line is 264 feet long and is designed to produce 0.25 lb plate up to 36-in. width at a maximum speed of 1000 fpm. With the assistance of automatic weight of coating control, pin hole and offgage detectors, it is possible with visual line inspection to bring through the prime piler, ready for packaging and shipment, more than 80 per cent of the line's production of 20 tons or more per hour. The modernized 0.50 lb line will now put 1.00 lb coatings on strip up to 36-in. width at 600 fpm.

"WIDE STRIP MILLS — EVOLUTION OR REVOLUTION?"

By FRANK H. FANNING, Vice President, Operations
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▲ PRODUCTION of wide hot rolled strip became possible as soon as engineers and operators were able to reduce to scientific terms the simple principles practiced as an art, but not understood, by the old time sheet mill rollers.

The discovery which made wide strip hot rolling practicable and which permitted much greater width to thickness ratios than previously thought possible was that the piece should have a slightly convex cross section and that each successive pass should have progressively less convexity, and that at least five factors controlling such a process were essential, namely:

1. The prepared contour of the rolls.
2. The temperature of the rolls.
3. The composition and springiness of the rolls.
4. The screw pressure applied to the roll necks.
5. The shape, composition and temperature of the piece.

The most important result of the proper control of these five factors was to provide equilibrium conditions by which this convexity formed a guide by surface contact for the sheet or strip, thus preventing its lateral movement, which would destroy the regularity of shape, or result in the sheets or strip running into the necks.

The original mill at Ashland, Ky., built to roll multiple length sheets, piled flat off the mill rather than coiled, would have resulted in the same failure and abandonment as did the Teplitz mill, or one later built and discarded by the United States Steel Corp. around 1904, had these principles not been recognized.

The following tabulation shows how the rolls were shaped in the original Ashland mill in recognition of the correct principles as detailed above:

TABLE I

Roll Shapes, Original Ashland Mill

Bar mill stands		Finishing stands	
Stand No.	Roll contours	Stand No.	Roll contours in. crown
1 Two-high	1/4 in. Concave	1 Three-high	0.018
2 Two-high	1/8 in. Concave	2 Three-high	0.016
3 Two-high	1/16 in. Concave	3 Three-high	0.014
4 Two-high	1/32 in. Concave	4 Three-high	0.012
5 Two-high	Straight	5 Three-high	0.012
6 Two-high	Straight	6 Three-high	0.010
7 Two-high	Flat Center 0.010 in. taper	7 Three-high	0.010

At this date, May, 1952, for one modern 80-in. hot strip mill, we must shape the rolls of the several roughing and finishing stands as shown in Table II to produce the correct "active" pass, and proper shape of the strip out of the last pass.

It is evident that some of the variables recognized in the operation of the earlier designed mills were made more nearly constant with the development of heavier, more powerful four-high mills.

With the disclosure of the correct principles of operating continuous wide strip mills, the four-high mill, having relatively small diameter work rolls, proved to be the most efficient mechanical means of producing the desired result. The application of roller bearings, and later the oil bearing, made the four-high mill the most effective rolling machine known for producing wide, thin strips, where higher separating forces are encountered than in any other rolled product. The four-high mill is a mill of free dimension where there is no restriction on the designer properly to proportion the roll diameters to carry the rolling loads.

Flat rolled products in 1923 amounted to 31 per cent of the total steel output of the country and totalled 11,606,814 tons, whereas in 1950 the total of flat rolled products had increased to 39,758,326 tons, and amounted to 53 per cent of all steel products produced.

A careful computation based on present-day labor and material costs, applied to old hand mill yields and processing operations, shows that 20 gage cold rolled would be selling today at $275 a net ton instead of the present price of $104 a net ton for the new and very much superior product.

Improved yields made possible by the new process really had a greater effect on economies passed on to the public than did increased production per man hour. Normal yields from ingots to finished 20 gage cold rolled sheet by the hand mill process could be expected to be around 48 to 49 per cent.

It is possible with modern strip rolling equipment to end up with an average 72 per cent of the ingot in prime 20 gage automobile sheets.

Present-day production of all flat rolled products at the old hand mill yields would require about 27,000,000 tons more ingot capacity than we have in the country

at the present time, or a total of over 140,000,000 tons.

It should be evident to any fair-minded analyst first that steel prices have not risen at the same rate as others, and second the price of steel is not the reason for the radical increases in selling prices of things made from steel.

Improvement in mechanical properties of flat rolled products kept pace with improved rolling practices.

Three major factors contributed to the improvement of the product: (a) chemistry, (b) rolling procedures, and equipment, and (c) heat treating facilities. Of these three, it is my own opinion the rolling procedures and equipment item was most important, because it made possible the improvement in the other two by the changed nature of the product.

Through all the years of wide strip development, the customer no sooner got a taste of an improvement in product than he demanded more.

It was found from experience that small rolls were capable of producing greater reductions per pass on account of the fact that the area of contact of the metal with the roll is less and, therefore, the resistance offered by the piece is less for the same amount of reduction. However, the resistance of a cylinder to bending varies with the cube of the diameter; therefore, the smaller the diameter, the greater the tendency to bend.

Lauth, in 1864, solved this problem by means of a three-high mill, in which the middle roll was of small diameter, while the top and bottom rolls were much larger, so that as material was passed back and forth, the top roll and bottom roll supported the middle roll.

Engineers, planning to roll strip and recognizing this principle, went a step further and designed a four-high mill, largely for the reason that in rolling strip, material does not pass back and forth through the same stand as was the case with the three-high mill. In fact, this same principle was embodied in some very large plate mills having rolls as long as 204 in. with backing-up rolls 50 in. and work rolls 34 in. in diameter. In this case all the rolls were driven.

In 1925, a four-high mill was installed at the Rome Brass and Copper Works in which the backingup rolls were driven solely by their friction with the working rolls.

In the more recent design of four-high hot mills there has been a trend to increase further the diameter of the work rolls in order to provide sufficient torque capacity in the work roll necks for increased power input. To increase work roll diameters increases the separating forces which in turn means higher bearing loads and increased spring in the mill. Work roll neck diameters seriously limit the power input into the mill, increasing the number of mills required in a mill train to make a given range of reduction in strip gage.

Computing the known power requirements for a fixed range in reduction of the strip gage, this amount of power could be applied to fewer mills in a train if it were not for the limited torque capacity of the work roll necks. Could not this be accomplished by driving the mill on all four rolls, applying a high percentage of the power to each of the backup rolls, and the remainder to each of the work rolls? The work rolls then could be reduced in diameter, without reduction in the diameter of the back-up rolls.

Is it absolutely necessary to apply all the power to the work rolls?

The value of the extremely small diameter work roll has been demonstrated on a cold mill rolling 2-in. wide strip to 0.000125 inch in a single thickness. The work roll diameter on this particular mill is only $\frac{1}{24}$ the diameter of the backup roll. In this particular instance the width of the strip is 16,000 times the strip thickness, whereas on an 80-in. mill rolling 0.030 x 72 inches wide, the strip width is 2400 times the strip thickness. The 80-in. mill would have to roll a 72-in. wide strip to 0.0045 in. to equal the performance of the small mill. The performance of this mill is good, as indicated by the gage/width relationship (16,000:1) and it should

TABLE II

Roll Shapes, Modern 80-In. Hot Strip Mill

Stand No.	Roll size and contour (inches)	Powered by
	Slab Mill	
Two-high	45 x 120 — Straight	Two 5,000-hp motors
	Bar Mill	
No. 1 2-High	34 x 80 — Straight 34 x 80 — Straight	1000-hp — 6600-v
No. 2 2-High	34 x 80 — Straight 34 x 80 — Straight	2500-hp — 6600-v
No. 3 2-High	34 x 80 — Straight 34 x 80 — Straight	4000-hp — 6600-v
No. 4 4-High	46 x 80 — Straight 20 x 80 — Straight 20 x 80 — Straight 46 x 80 — Straight	5000-hp — 6600-v
No. 5 4-High	46 x 80 — Straight 20 x 80 — Straight 20 x 80 — Straight 46 x 80 — Straight	4000-hp — 6600-v
	Strip Mill	
No. 1 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	4000-hp — 600-v d-c
No. 2 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	4500-hp — 600-v d-c
No. 3 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	4500-hp — 600-v d-c
No. 4 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	4500-hp — 600-v d-c
No. 5 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	4000-hp — 600-v d-c
No. 6 4-High	49 x 80 — Straight 23 x 80 — 0.005-in. convex 23 x 80 — 0.005-in. convex 49 x 80 — Straight	3000-hp — 600-v d-c

serve as an example for improvement in design for four-high mills to roll all commercial widths and gages required by the trade.

Should we find it practicable to build a mill having work roll diameters of say 1/10 the backup roll diameter, having a four-roll drive, we would:

1. Reduce the separating forces.
2. Lower the backup bearing loads.
3. Extend the life of the backup bearings due to lower RPM.
4. Place no limit upon power input.
5. Reduce mill spring (because of No. 1).
6. Secure more accurate and uniform gage (less mill spring).

Recognizing the advantage of small work rolls, some inventors have designed cluster mills for cold reduction. While cluster mills have some mechanical complications, they have been a valuable tool when applied to the rolling of certain special products.

For universal application, however, there is considerable advantage in the "free dimensioned" backup, or supporting rolls of the four-high mill over the dimension limited backup rolls in even the most simple roll arrangement of a cluster mill.

To illustrate the relative strength capacity of each type of mill, work rolls of decreasing dimensions are shown in Figure 1, namely, 15-in., 12-in., 9-in., and 6-in. diam.

The decreasing separating force due to reduction in work roll diameters is identical in each type of mill.

Since the backup roll dimensions of the four-high may remain constant, and the separating force declines

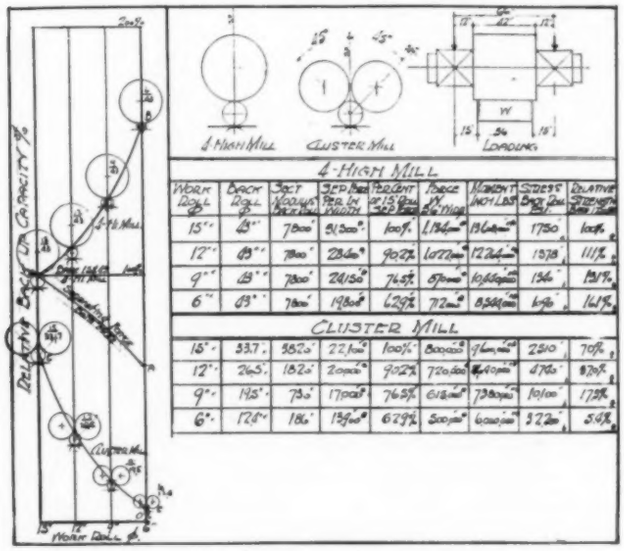

Figure 1 — Chart shows the relative backing capacity of 4-high mills vs cluster mills.

with work roll diameter, the ability of the four-high mill to resist these forces increases at a rapid rate.

In building a cluster mill, the engineer must design the backup rolls to fit the available space, which is limited by the side-by-side arrangement of these rolls.

An examination of the relative loads and stresses indicates quite clearly the flexibility of the four-high mill design over any other known arrangement where the number of rolls used exceeds four.

Another line of development possible is through the application of electronics to control of screw setting.

On four-high continuous strip mills where the rolling is in one direction, the strip gage is not uniform from end-to-end of the strip. This undesirable condition is much less on the reversing hot strip mills where the colder trailing end enters the mill first on the next pass.

It is desirable automatically to control both the mill screw and the strip tension between stands to insure uniform gage throughout the length of the strip.

Little work has been done to develop such a control, but with the introduction of the X-ray gage as a source of intelligence it should be possible for a bright young electronics engineer to contribute a major improvement to the new "science" of flat rolling.

A similar need is indicated for front and back end gage control on cold strip rolled on tandem mills. This is a source of considerable waste in heavy-to-gage ends, which must be trimmed off the coil before it can be shipped to the customer.

"THE UGINE-SÉJOURNET EXTRUSION PROCESS"

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▲ THE production of bars, shapes and tubes of steels by hot extrusion has been under consideration in most industrial countries for more than 25 years and has been most intensively studied by an important French steel producer, the Acieries Electriques d'Ugine. Tests conducted by this company as early as 1925 indicated that steel can be extruded under suitable conditions equally as well as many nonferrous metals. Actual commercial operation, however, was not accomplished in view of the rapid wear and seizing of tools which usually were able to function satisfactorily for only a single operation, while sometimes not even one successful bar or tube could be obtained.

In undertaking continued experimentation in this field, Ugine had three objectives:

1. The production of unbalanced sections (both hollow and solid) of the types ordinarily extruded from copper-base and aluminum-base alloys, often in complex forms that either cannot be rolled, or if so, would require quite complicated rolling equipment. An outstanding example is tubing for the manufacture of hollow turbine blades.

2. Conversion into the desired forms, of steels, or of combinations so high in alloying content that they may not properly be called steels, which cannot be rolled at all, or are rollable only with great difficulty and customarily with very low yields.

3. The production of sections and materials readily rollable, but in such small quantities that the cost of rolls and, in some cases, even the cost of changing a set of rolls cannot possibly be justified by the small quantities involved. This is economical in the case of extrusion because of the very low cost of the required tools and the speed with which die changes are effected.

The problem was attacked in the direction of improving the lubrication, but the conclusion was reached that actually there was not one, but two problems in this field that required solution; namely, the lubrication between the billet and the container and between the billet and the die. Many lubricants, both those in current use and others, were tried, including materials of mineral origin as well as those produced from animal and vegetable raw materials. Neither those that were solid at the operating temperatures, nor those that were liquid gave satisfactory results, and the latter seemed to have much too high fluidity. Furthermore, it was observed that under operating conditions materials containing carbon, instead of lubricating, appeared actually to promote seizing of the billet and the tools. They came, therefore, to the absolute requirement of carrying on subsequent experiments only with carbon-free materials and, more particularly, those melting at quite high temperature.

It was these experiments that led to the discovery that glass, introduced in solid form, was a most useful lubricant and simultaneously served as an insulator, thus effectively protecting the tools from contact with the billet and with the section in course of extrusion, and also from absorption of too much heat therefrom. Later came the concept that any related substance possessing adequately high softening point and adequate viscosity at the operating temperature, and melting over a range of temperature, could supply the necessary qualities. This is the concept that has now been put into practice.

In the early stages of these experiments with various inorganic substances, it became obvious that numerous conditions of the extrusion operation exerted a very great influence upon the results obtained, but the part played by each factor was difficult to appraise in view of the great number of variables involved and their interdependence. Among them may be mentioned: extrusion speed, quantity of glass used, glass viscosity, metal temperature, extrusion pressure, extrusion ratio, and others. To establish all these relationships, many tests and extensive mathematical analyses were required. With the changes in the intervening years and with conditions constantly improving, most of this work has been completed while additional experiments indicated by the earlier results have also been undertaken, so that today a satisfactory industrial process has evolved.

EXTRUSION PRESSURE

The formula expressing the pressure necessary to effect extrusion of a given metal at a given temperature was established theoretically and then verified by actual trials. This formula sets forth the specific pressure applied to the billet in relation to the extrusion ratio, to the coefficients of friction that are concerned, and to the inherent resistance of the metal to deformation at the selected temperature. The formula was readily checked by pressure measurements during extrusion, while studies of pressure changes in turn threw further light upon the coefficient of friction. As a result, many families of curves have been developed showing the resistance to deformation as a function of temperature for many well known steels and other high temperature alloys and these data have been correlated with creep values for these materials. Much of these data have been combined in nomographic charts and set forth together on a circular slide rule.

The combined results of all these experiments have permitted predetermination of the characteristics and possibilities of extrusion by various sizes of presses, and have likewise indicated the ability to undertake the manufacture of various designs of products in the many steels that have been studied.

DEFORMATION DURING EXTRUSION

The staff of C.I.E.P.M. has developed a new method for precise study of the mode of deformation of metal during extrusion.

Mathematically, the results of these tests have been expressed in formulae that make it possible now to determine precisely the position of a point in an extruded bar when its previous position in the billet is known.

GLASS

Hundreds of tests undertaken with various kinds of glass and glass-like material pointed to the predominant influence of glass viscosity and glass diffusibility. The quality and quantity of glass employed is also most influential.The latest studies have shown, however, that the physical form of the glass may be altered advantageously; hence the original glass plate used against the die and the glass "test tube" used around the mandrel (for tubes) have been replaced by fibrous or woven glass of the simplest possible form.

HEATING OF BILLETS

Wear of the dies, die holders and container liners is very rapid when the surface of the billets is covered with oxides.

Obviously then, such surface oxide cannot be tolerated if die wear is to be retarded. This problem of surface oxide has been solved, at least temporarily, by final heating in a salt bath, thus removing any oxides formed during preheating while at the same time giving uniform and controlled temperature. Other solutions of the problem are in process of completion and new methods are to be expected.

EXTRUSION SPEED

To those familiar with the extrusion of nonferrous metals, more particularly copper-base and aluminum-

base alloys, there is an element of surprise in witnessing this successful extrusion of steel. Speed plays an important part in the success of the operation and the rapidity with which the bars or tubes or shapes issue from the die is an element of novelty. Steel and related alloys must be extruded very rapidly.

"A STUDY OF TESTS FOR THE EVALUATION OF COKE"

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▲ THE ultimate aim of the study of the chemical and physical properties of blast furnace coke is the precise definition of the ideal combination of properties that the coke should possess, and establishment of methods of test for these properties. In actual practice, however, meeting the ideal, if such is found to exist, may be economically unsound or even impossible. The degree to which the coke properties may depart from the ideal may be a minor consideration in comparison to the maintenance of uniform coke quality. Furthermore, the ideal combination of properties may differ for furnaces of different size and for different burdens.

Coke, which is irregular in size and bulk density, may give rise to fluctuations in the thermal balance of the blast furnace when the coke is charged by volume. Similar fluctuations will be caused by variations of moisture and ash content when coke is charged by weight. Variability in ash means variability in slag composition. In a furnace with high sulphur input, where variation in slag composition may be critical, variation of the ash content of coke might interrupt the smooth working of the furnace.

Extreme variations in coke strength, as measured by established physical coke tests, may give rise to large variations in the degree of degradation of the coke within the furnace. The resistance to degradation in the furnace determines to a large extent the stack permeability and the amount of channeling of the gas flow in the furnace. In turn, the temperature and degree of preparation of the iron is dependent on the time of gas to solid contact in the stack. It follows, therefore, that wide fluctuations in the quality of the iron produced can be caused by variations in coke physical strength.

Irregular furnace operation can, of course, be due to causes lying outside the realm of coke quality control. Other causes could include a failure to maintain a regular charging schedule, faultily designed or an inadequate plant and inadequate or improper preparation of the burden.

Since, however, coke occupies some 60 per cent of the furnace volume, the necessity for the maintenance of a uniform quality of coke must be stressed.

Variations in the measurement of a property of a coke may arise from one or more of the following causes: (1) changes in raw materials, (2) changes in plant practice, (3) sampling errors, and (4) testing errors. It was considered essential to evaluate the errors of the tests in order to establish whether variations observed in the determined values of the properties assessed were or were not due to the assignable causes such as in raw materials or plant practice.

The coals tested were mined in eight main regions, namely: (1) western Pennsylvania and northern West Virginia, (2) central Pennsylvania, (3) southern West Virginia, (4) eastern Kentucky, (5) southeastern Illinois, (6) Alabama, (7) Oklahoma and Arkansas and (8) Utah.

The moisture contents of the individual coals ranged from 1.6 to 11.0 per cent. Excluding the washed anthracite culm used by the Ford Motor Co., the moisture contents ranged from 1.6 to 8.5 per cent. Within this range, the reported moisture contents do not appear to depend on the volatile matter content or size of the coal.

The volatile matter contents of the high volatile coals ranged from 32.8 to 42.6 per cent on the dry, ash-free basis. The low volatile coals, on the same basis, ranged from 16.0 to 21.2 per cent. The four medium volatile coals used ranged from 22.6 to 27.4 per cent volatile matter. The volatile matter of the dry, ash-free anthracite culm was 7.3 per cent.

The sulphur contents of the coals on the dry, ash-free basis ranged from 0.56 per cent for the Pocahontas No. 3 Seam coal from McDowell County, West Virginia to 2.78 per cent for the Freeman Coal from No. 5 Seam in Illinois. The southern West Virginia and eastern Kentucky coals had the lowest dry, ashfree sulphur contents ranging from 0.56 to 1.13 per cent, two coals with sulphur contents of 1.21 and 1.25 per cent being excepted. The northern West Virginia and Pennsylvania coals had the highest dry, ash-free sulphur contents, ranging from 1.17 to 1.85 per cent; three coals with sulphur contents of 0.70, 0.82 and 0.94 per cent being excepted. The dry, ash-free sulphur contents of the Illinois, Alabama and Utah coals ranged from 0.69 to 1.21 per cent, excepting the high sulphur No. 5 Seam Illinois coal. On the same basis the sulphur of the Oklahoma and Arkansas coals ranged from 0.72 to 1.78 per cent.

The range of volatile matter contents between maximum and minimum values reported for the individual coals making up a single coal blend was from 6.0 to 24.1 per cent, excluding from consideration coke breeze, anthracite culm and coal tar pitch. Excluding the high value of 5.7 per cent at the Ford Motor Co., where sixteen coals were blended, the maximum day-to-day range of volatile matter content of the prepared blends was from 0.8 to 4.0 per cent. Similarly, the range of ash contents between individual coals was from 1.4 to 7.7 per cent and the range of ash contents of the blends was from 0.7 to 2.6 per cent. The fact that coals of such extreme ranges of quality and analysis were being used to produce acceptable metallurgical coke, after the

TABLE I

Fuels Used for Coke Production

State	I — COALS			
	High volatile		Low volatile	
	Seam	County	Seam	County
Alabama	American	Jefferson		
	Mary Lee	Jefferson		
	Pratt	Jefferson		
Arkansas			Excelsior	Sebastian & Crawford
Illinois	No. 5	Williamson		
	No. 6	Williamson		
Kentucky	Alma	Pike		
	Elkhorn	Pike & Floyd		
	Harlan	Harlan		
	Pond Creek	Pike		
Oklahoma			Lower Hartshorne	Le Flore
Pennsylvania	Pittsburgh	Fayette, Greene & Washington	"C" Prime	Somerset
			Lower Kittanning	Cambria
			Miller "B"	Somerset
Utah	Sunnyside	Carbon		
West Virginia	Eagle	Fayette & Logan	Beckley	Raleigh
	Glen Alum	Mingo	Davy-Sewell	McDowell
	Pittsburgh	Marion	Pocahontas No. 3	McDowell, Mercer, Vivian & Wyoming
	Powellton	Fayette & Raleigh		
	Sewell	Randolph	Pocahontas No. 4	Raleigh

Inerts	II — INERTS					
	Used by	% in mix	Proximate analysis			
			% V.M.	% F.C.	% Ash	% Sul
Anthracite	Ford Motor Co., Dearborn, Mich.	5.0	6.4	80.9	12.7	0.73
Coke breeze	Brooklyn Union Gas Co., Brooklyn, N. Y.	2.0				
Pitch	Geneva Steel Co., Ironton, Utah	3.5				
Pitch	Geneva Steel Co., Provo, Utah	4.5				

proper admixture of additives and/or the proper blending and preparation of the coals themselves, is noteworthy.

CONCLUSIONS ON COKE TESTING PROCEDURE

One of the principal objectives of the coke evaluation project was to determine which of the commonly applied coke tests overlapped or paralleled each other. The correlation studies revealed several instances of significance.

In determining the correlations between the 2-in. screen index of coke and the other factors no significant difference was found when the 3-in. screen index of coke was substituted. The important point is that there is a direct and predictable relationship between the various screen fractions of a particular coke.

The correlation factor between the 2-in. screen index and the 2-in. shatter index of coke was found to be 0.98, and when the 3-in. screen index was substituted for the 2-in. screen index the factor was found to be 0.91, either one of which indicates that these factors, the 2-in. screen index and the 2-in. shatter index, indicate exactly the same thing with respect to measuring coke strength.

In comparing the 2-in. screen index with the tumbler stability index (plus 1-in. coke) a correlation factor of 0.86 was obtained, which again indicates that the 2-in.

screen test and the tumbler stability give exactly the same information.

When the 2-in. screen index was compared with the tumbler hardness index (+ ¼-in. coke) no correlation was established, indicating that these two tests measure different properties.

The special shatter tests (eight drops) although more precise than the ASTM standard test did not reveal any significantly new information. This also applies to the permeability data.

The elimination of any of the tests from the originally recommended procedure was developed only after the complete analysis of the data by the Evaluation Committee of the Coke Evaluation Project.

Table III shows coke tests eliminated and recommended by the evaluation committee.

COKE TESTS RECOMMENDED

Moisture—It is recommended that the moisture be determined on a 1000-lb sample of plus 1-in. coke in the permeability cylinder. Generally this will permit the sample to be dried in about one hour's time. The influence of this factor is directly assignable, that is, the coke as a fuel suffers in direct proportion to the moisture content.

Volatile matter—The reactivity of a coke increases with an increase in volatile matter content of the coke and the coke becomes softer as the volatile matter increases.

Ash—Ash must be considered a diluent of the available carbon in coke and is, therefore, considered totally undesirable from a fuel standpoint.

The quality of coke is directly affected by the ash content and additionally (as with moisture) additional fuel is used to flux the ash and limestone required for its release.

Sulphur—Sulphur is another factor which is undesirable in a coke and represents from 90 to 97 per cent of the total sulphur in the burden to the blast furnace.

Screen index—The 2-in. screen index is recommended because this index reflects the native fissuring of the coke and is a composite of the coals used, carbonizing temperature, coal pulverization, coal bulk density and ash content.

Tumbler (Modified)—The tumbler hardness index, the + ¼-in. coke at 400 revolutions is recommended because it shows low correlation with breakage char-

TABLE II

Mixtures Charged in Coke Ovens

	Carnegie	Carnegie	J & L	Bethlehem	Brooklyn	Interlake	Ford	Inland	Republic	Geneva Provo.	Geneva Ironton	Koppers
	C1*	C2#	J	B	BG	I	F	S	R	G	T	K
High and medium volatile												
Alabama									100.0			
Illinois												78.0
Kentucky						40.0	64.0	65.0				
Kentucky (stock)						38.0						
Pennsylvania	100.0	100.0	67.8	7.8								
Utah										80.5	96.5	
West Virginia			15.7	61.5	82.0		21.0					7.0
Total H.V. and M.V. Coals	100.0	100.0	83.5	69.3	82.0	78.0		65.0	100.0	80.5	96.5	85.0
Low volatile												
Arkansas										15.0		
Oklahoma												
Pennsylvania				30.7								
West Virginia			16.5		16.0	22.0	10.0	35.0				15.0
Total low volatile coals			16.5	30.7	16.0	22.0	10.0	35.0				15.0
Inerts												
Anthracite (Pa.)							5.0					
Coke breeze					2.0							
Pitch										4.5	3.5	
Total inerts					2.0		5.0			4.5	3.5	
Grand total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* 100% Raw Leisenring Coal. # 100% Washed Robena Coal.

TABLE III

Coke Tests Eliminated and Recommended by the Evaluation Committee

Tests eliminated	Tests recommended
1 — Moisture (each screen fraction)	1 — Moisture (gross sample + 1-in. coke)
2 — Shatter, standard	2 — Volatile matter (+ 1-in. coke)
3 — Shatter, special	3 — Ash (+ 1-in. coke)
4 — Tumbler, standard	4 — Sulphur (+ 1-in. coke)
5 — Apparent sp gr (+ 1-in. coke)	5 — Screen (total per cent plus 2 in.)
6 — True sp gr (+ 1-in. coke)	6 — Tumbler, special — hardness index (+ ¼ in. after 400 revolutions)
7 — Void volume (+ 1-in. coke)	7 — Bulk density (+ 1-in. coke)
8 — Air permeability (+ in. coke)	
9 — Reactivity indices	

acteristics, which suggests that it may be measuring some other factor, such as attrition.

The original intent of the tumbler was a measure of attrition but the test data clearly reveals that the commonly used stability index (plus 1-in. coke) at 1400 revolutions measured the same factor as the screen index and the shatter index.

Bulk Density—Current standard methods for measuring this factor are inaccurate and low due to the small quantity of coke used and the shape of the container. To measure this factor the permeability cylinder is recommended because it has a cubic content of 28 cubic feet, or 3½ times larger than the present container.

Bulk density is affected both by coke size and size consistence and apparent specific gravity.

A tabulation of the seven physical and chemical tests recommended by the Evaluation Committee, is given for the 12 complete tests, in Table IV, listing physical and chemical tests recommended by the Coke Evaluation Committee.

CONCLUSIONS AND RECOMMENDATIONS

It was the intention to recommend a formula that would correlate good or bad coke with good or bad blast furnace practice.

Several formulae for the evaluation of blast furnace coke were suggested by the committee and these were tabulated, ranked and discussed by the general committee.

The final analysis of these formulae indicated that variations in the 11 plants caused deviations within the scope of any one of the suggested methods. This was especially true when an attempt was made to correlate blast furnace performance with other plants.

However, after considerable deliberation and study the committee finally approved the following on November 2, 1951:

"That no formula for coke evaluation should be included in the report of the Coke Evaluation Project. The seven factors, i.e.:

1. Moisture (gross + 1 in.).
2. Volatile matter (dry).
3. Ash (dry).
4. Sulphur (dry).
5. Screen index (plus 2 in.).
6. Tumbler, modified (plus ¼ in. after 400 revolutions).
7. Bulk density (dry).

should be pointed out as those required to evaluate coke, and that all plants are requested to determine these factors according to the methods described in the Coke Evaluation Project report during the period of one year. At the end of the year, each plant is requested to report on how well these seven factors evaluate coke."

TABLE IV

Physical and Chemical Tests Recommended by the Coke Evaluation Committee

Plant	Symbol	Physical tests			Chemical tests			
		Screen-test (%+2 in.)	Tumbler hardness (%+¼ in.) after 400 revolutions	Bulk density (dry coke) lb/cu ft	% moisture	% volatile matter (dry)	% ash (dry)	% sulphur (dry)
Carnegie	C1	59.4	79.6	27.4	7.0	1.05	17.65	1.15
Carnegie	C2	72.6	80.2	27.8	4.5	1.05	11.98	1.38
J & L	J	74.7	82.6	24.9	11.3	0.92	9.79	0.98
Bethlehem	B	79.0	84.6	24.7	4.3	1.26	11.32	1.02
Brooklyn	BG	79.8	80.1	27.6	6.7	0.70	8.74	0.73
Interlake	I	82.6	82.5	23.8	4.6	1.29	8.49	0.72
Ford	F	81.4	78.6	25.2	7.7	0.66	10.47	0.54
Inland	S	82.4	82.2	23.6	7.3	0.84	9.70	0.78
Republic	R	84.2	84.1	26.2	5.5	0.45	14.23	0.82
Geneva-Provo	G	76.4	78.4	22.9	4.1	0.59	10.32	0.91
Geneva-Ironton	T	54.8	79.0	21.5	7.1	0.52	11.05	0.91
Koppers	K	85.4	82.5	23.1	6.6	0.75	11.63	0.89

"RECENT EXPERIMENTS IN THE RECOVERY OF MANGANESE"

By SHADBURN MARSHALL, Research Associate
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▲ OPEN hearth slags are potentially our largest continuing domestic source of manganese. This was quickly recognized by the American Iron and Steel Institute, and it accordingly appointed a subcommittee to investigate methods of recovering manganese from slags. Activities were started in early 1949 and are continuing. At present, three different processes are being evaluated. The progress that has been made on each will be described separately.

UNITED STATES BUREAU OF MINES PYROMETALLURGICAL PROCESS

Initially, the subcommittee elected to investigate a pyrometallurgical process consisting of two steps. It was necessary to determine (1) whether or not a burden of open hearth slag could be smelted in a blast furnace to produce a spiegellike material that would contain most of the metallics present in the slag; and (2) whether or not such a product could be selectively oxidized to separate manganese from phosphorus, yielding a slag, or concentrate, suitable for smelting to ferromanganese in a blast furnace.

To investigate the first step of the process, the smelting of open hearth slag, a small blast furnace was constructed. This furnace was operated intermittently for 68 days in campaigns ranging from one or two days to about two weeks in duration. During periods of satisfactory operation, this furnace was flushed hourly, and a cast was made about every three hours. The weight of a cast was about 1000 lb with some variation depending on how the tap hole was opened. In a 24-hour period the furnace produced about 3½ tons of metallic product.

Details of furnace and stove construction are evident in Figure 1.

A typical campaign under relatively stabilized conditions is shown in Figure 2.

During a subsequent campaign, anthracite coal was substituted for part of the coke in amounts ranging from 25 to 100 per cent of the total fuel. Although the use of this material as a replacement for coke was not fully investigated, it quickly became evident that this fuel was unsuited for use in the small furnace. Furnace pressures promptly increased and lack of reduction was evidenced by the fact that the manganese content of the blast furnace slag became much higher than when operating with coke.

As a result of these operations it can be concluded that open hearth slags can be smelted in a blast furnace to metal containing 15 to 23 per cent manganese. The manganese recovery in the spiegeleisen was about 60 per cent of the manganese charged. Losses in blast furnace slag amounted to about 14 to 24 per cent of that charged, while losses as flue dust were from 6 to 17 per cent. Unaccounted for losses were in the range 5 to 11 per cent.

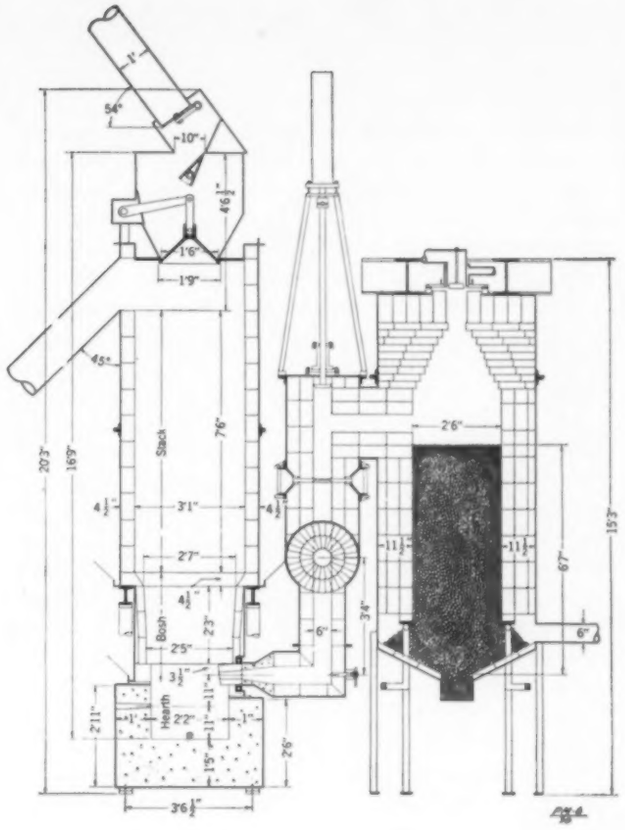


Figure 1 — Sketch shows details of furnace and stove developed by U. S. Bureau of Mines for smelting open hearth slag.

The coke required per ton of metallic product varied between 3200 and 4500 lb., and although the per cent manganese recovery in the spiegel was not dependent on the manganese content of the slag charged, the lower coke rates were obtained when slags high in iron and manganese were smelted. The results obtained with anthracite as part of the fuel were discouraging in view of the present coke shortage.

The work on the second step of the process, the selective oxidation of a spiegel, to separate phosphorus and manganese, used a 500-lb capacity surface-blown converter with a magnesite lining.

Initial attempts to oxidize the metal to a residual manganese content of about one per cent resulted in failure because, when the manganese content approached this low value, the slag contained too much phosphorus to classify as ferromanganese-grade ore. Lower phosphorus slag resulted in poor manganese recovery.

As a result of the initial tests a two-stage, or cyclic, process was developed. This process involves oxidizing the manganese to a low value, about one per cent,

after which the metal is removed, the slag being retained in the converter. A new batch of spiegel is then charged into the converter, whereupon the reaction between the retained high-manganese slag and the silicon in the new spiegel reduces the prosphorus content of the slag to values of less than 0.1 per cent. At this point, or after a slight additional oxidation, the slag is removed from the vessel. The slags easily meet the manganese and phosphorus requirements for high-grade ore. The silica content of the slags is well above the requirement; however, as an alternative, the process can be operated to produce a viscous low-silica slag that will contain a large amount of entrapped high-phosphorus metal shot which must be removed. It therefore becomes a matter of economic balance as to which practice is the less objectionable; that is, whether to use high-silica slags low in phosphorus or to employ low-silica slags containing shot that must be removed as a separate step in the process.

In the cyclic process, 75 to 80 per cent of the manganese appears in the slag, 5 to 10 per cent in the blown metal, and 2 to 4 per cent in the gases. The remaining 5 to 15 per cent represents miscellaneous losses such as spillage, ejections, and the like.

The above-described experiments demonstrate this two-step process to be technically feasible. It may be safely estimated that recovery of the manganese values from open hearth slags should be more efficient in larger stabilized units. Future plans for this process include the operation of the oxidizing step on a 2000-lb scale and possibly the smelting of some of the slags produced in this step in the small blast furnace. In this manner, more accurate data for an economic evaluation of the process will be obtained.

UNITED STATES BUREAU OF MINES AMMONIUM CARBONATE LEACHING PROCESS

The second process in which the AISI subcommittee became interested was a chemical process involving the leaching with ammonium carbonate of open hearth slags pretreated by clinkering with lime.

Briefly, the process incorporates the step of clinkering slag with lime or limestone at a temperature of about 2300 F to produce a product with a $\frac{CaO—3P_2O_5}{SiO_2}$ mol ration of about 2.0. The resulting material is then subjected to a reducing roast at about 1300 F in order to convert the manganiferous material to MnO. Subsequent to the reducing roast, the product can be ground and leached with ammonium carbonate solutions. Manganese is recovered from the leaching solution as manganese carbonate by elimination of ammonia, which can be subsequently reused.

To date the clinkering step has been scaled up to 1000-lb charges in a rotary kiln, the reduction step has been carried out on 160-lb batches with hydrogen as the reducing agent, while the leaching and ammonia recovery steps have been confined to the use of a few lbs of material. Some experiments have been conducted with gases other than hydrogen.

The slags used in these experiments were open hearth flush slags.

The data indicate that higher clinkering temperatures lead to a somewhat better extractability of manganese on leaching. On the other hand, the manganese-to-iron ratio becomes less favorable, indicating that more iron is leached as the clinkering temperature is increased.

A highly reducing atmosphere is essential for high manganese recovery as well as for a suitable Mn/Fe ratio in the final product. Laboratory studies are now under way at College Park to evaluate thoroughly the use of $CO-H_2$ mixtures, which can be prepared from natural gas, for the reduction step of the process.

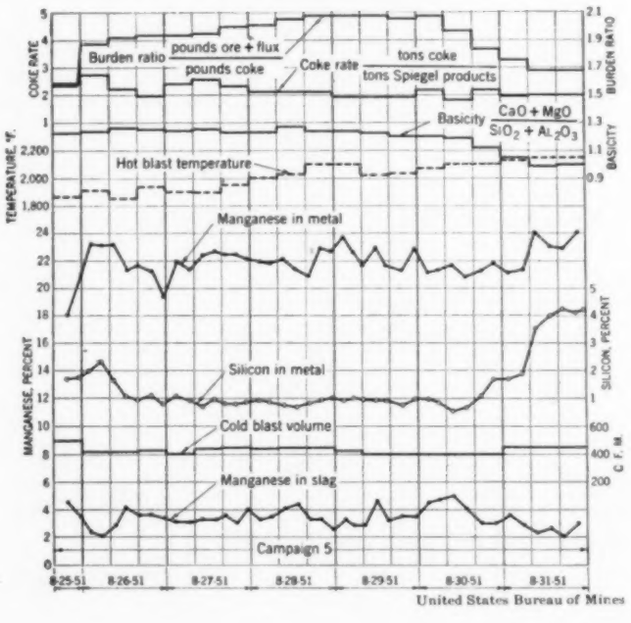
As in any chemical process utilizing a somewhat critical reagent such as ammonia, ability to recover and reuse the reagent is of paramount importance in determining its technical feasibility and economic practicability. In the process under discussion, the ammonia is recovered by distillation of the pregnant leaching solutions. This causes the simultaneous precipitation of manganese as the carbonate. Studies of ammonia stripping and manganese recovery have disclosed that as much as 70 per cent of the manganese precipitates when 40 to 50 per cent of the ammonia is expelled by distillation at temperatures of 50 to 100 C. Under these conditions, manganese: iron ratios in the precipitate range from 15 to 20; manganese: phosphorus ratios are 2400 or higher.

Means of purging the recirculating leaching solution, which contains some manganese and ammonia, of the iron and other impurities dissolved in the leaching step have yet to be found. Studies in this direction are included in future plans. These plans also include scaling up the reducing, leaching, and ammonia stripping steps to the point that accurate material balances can be made.

MANGANESE RECOVERY FROM SLAGS BY CHLORIDIZATION

The third process to be discussed utilizes both pyrometallurgical and chemical techniques. In brief, it consists of treating slags with either solid or gaseous chlor-

Figure 2 — Results of a typical campaign under relatively stabilized conditions are given in this chart.



ides, at a temperature that will cause the volatization of iron and manganese chlorides and leave behind all gangue material. The volatilized chlorides may be condensed on a cold surface or dissolved in water for subsequent separation to produce a very pure manganese oxide and either a high-grade iron powder or iron oxide. The chloride reagent is simultaneously recovered for reuse.

To date, experimental work has been confined to small laboratory runs, and the chloridizing agents have been HCl gas and anhydrous $CaCl_2$. Flow sheets have been prepared for these processes. One process employs HCl as the reagent, and was originally suggested to the manganese subcommittee by Armco Steel Corp. The other process using $CaCl_2$ was proposed by the United States Steel Co. This reactor differs from that for the HCl process in that a flush gas will have to be provided. In small scale experiments nitrogen has been satisfactory for this purpose. Such small scale experiments have indicated that under the conditions described, 89 per cent of the manganese can be recovered with amounts of $CaCl_2$ equal to the stoichiometric requirements of the iron and manganese in the slag.

For the future it is not planned to build either of these chloridizing processes to pilot size. Rather, the critical parts of each will be scaled up and studied intensively with the thought that the best features of each may be incorporated into a practical unit.

SUMMARY

Experimental work done within the last two years with American Iron and Steel Institute assistance and sponsorship has demonstrated that at least three processes for the recovery of manganese from open hearth slags are technically feasible. As work progresses, each of these processes will be scaled up to a sufficient degree to determine its practicability and economic value in the event of an emergency.

"CARBON REFRACTORIES FOR BLAST FURNACES"

By JOHN J. HAZEL, Chief Ceramic Engineer

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▲ THE change from ceramic to carbon for blast furnace lining was sudden and quite extensive, and was primarily an attempt to reduce or eliminate hearth breakouts. During the war years, 1941 to 1945, there were many serious hearth breakouts throughout the industry. A breakout, regardless of size, is always of considerable danger to the blast furnace operators. In addition, a hearth breakout can cost thousands of dollars in damaged equipment and the loss of valuable and much needed production.

In the British Iron & Steel Institute Special Report No. 30, George D. Elliot and Dr. John Chester have formulated a very excellent theory as to the causes of breakouts.

This theory may be expressed in a few sentences. Due to the high ferrostatic head the iron is forced into the open pores of the fire brick. Carbon monoxide in the furnace will come in contact with air and water vapor in the vicinity of the tap hole which in turn will form a gas rich in CO_2 in the pores of the brick and in contact with the Fe also in the pores of the brick. The resultant is the formation of a liquid FeO slag layer just behind the working face of the furnace hearth. Since this layer is unsupported it will be wiped off by the iron in the furnace hearth. This in turn exposes a new FeO zone and the process is continuous.

Carbon hearth installation started with five furnaces in 1945 and increased to a peak of 35 furnaces in 1948, then dropped down to two furnaces in 1951, and is now going back up with a possible 20 or more furnaces in 1952.

In 1948, there were a few serious carbon hearth breakouts in what many in the industry were beginning to think was a breakout-proof blast furnace hearth. The resultant decrease in carbon installation was as rapid as the original increase. News and rumors of breakouts traveled very fast, with the result that many began to question the protection and economy so highly claimed and advertised for carbon hearth construction.

In summing up the findings of the examination of many furnaces it was found that in all cases, with but one exception, the side wall carbon blocks were in excellent condition, showing little or no wear. In all cases there was considerable erosion and loss of carbon in the vicinity of the iron notch. This eroded area varied in shape from what we can call a saucer to that of a funnel. In other words, the eroded area at the iron notch was from 3 to 5 feet wide, 4 to 6 feet high and ranged from 1 to 25 inches in depth. Some vertical joints in the side wall blocks showed slight erosion and replacement with small fins of iron.

The examination and study of the carbon bottom blocks was not as complete as would have been desirable, due to the fact that in most cases there was an iron salamander of undetermined thickness on top of the blocks. On the few furnace hearths drilled, there was observed in the center of the hearths a loss of carbon due either to erosion or the dislocation and floating of the center blocks.

As just stated, in all carbon hearths examined there were oxidation and loss of carbon in the vicinity of the tap hole, and the logical explanation could be that the water used in the tap hole clay is decomposing and oxidizing the carbon blocks in that vicinity.

Data generally support the following points of view:

1. That H_2O in the vicinity of the iron notch is a powerful factor in the oxidation of carbon refractories.
2. That there exists in the carbon refractory in the

vicinity of the tap hole oxidizable material that can decompose H_2O and remove O_2 from the gases forming non-volatile oxides.

3. Conclusion 2 supports the hypothesis that iron oxide can be formed at some distance from the outer face of the carbon refractory and that the temperatures at which this oxidation is occurring are at or below temperatures of 1300-1400 F.

TESTS

The American Iron and Steel Institute authorized funds and made arrangements to measure the thermal conductivity of various blast furnace refractories at temperatures ranging from 300 to 600 F.

The results of some of these tests are as shown in Table I.

TABLE I

Interpolated Thermal Conductivities for Five Blast Furnace Refractories

Type of refractory	Thermal conductivity(a)			
	300 F	400 F	500 F	600 F
Blast furnace carbon block				
Foreign manufacture				
Transverse direction	29	30	31	32
American manufacture				
Transverse direction	71	73	75	76
Longitudinal direction	70	71	71	72
Ceramic blast furnace brick				
Ky. reg. burn brick	10.2	10.3	10.4	10.5
Ky. cone 18 burn brick	10.5	10.6	10.7	10.8
Missouri cone 23 burn	13.3	13.3	13.3	13.3

(a) Btu/hr/sq ft/in./degree F

(Data from Battelle Memorial Institute)

DESIGN DETAILS

Although some operators still advocate the all-carbon tap hole, the majority feel that ceramic materials are needed as a ring or insert. Many of the all-carbon tap holes have produced high tonnage with little or no trouble. Since most blast furnace operators open the tap hole by means of the oxygen lance and then use a clay with 10 to 20 per cent moisture content to stop the hole, it seems logical to use a small section of ceramic material in this location.

The all-carbon tap hole is not used in Germany or England.

The use of carbon in the bosh and above the mantle has come in for its share of importance in the past few years. The small furnace at Chester, Pa. was lined with carbon up to the mantle but it was operated only four months, then banked and allowed to stand for approximately 18 months. C. E. Agnew stated the side wall of the bosh was very smooth and only one spot three feet in length at the mantle was badly eroded. This was not a fair test of carbon used in the bosh.

In the Chicago area there are plans under way to line a large furnace with carbon brick up to 35 feet above the mantle. This first (in this country) installation of carbon above the mantle will be watched with considerable interest.

Only the British have had experience on the use of carbon in the blast furnace stack. Chesters and MacKenzie comment on their experience at the Appleby-Frodingham Steel Co. at Scunthorpe, England, by stating there has been an increase in tonnage from the all-carbon furnaces.

Furnaces 1, 5 and 6 of the Appleby-Frodingham Steel Co. made 8.27 per cent, 3.33 per cent and 11.43 per cent respectively more iron than on the previous campaigns. One explanation is that the carbon linings, being thinner in comparison with ceramic, permitted the larger volume, and therefore more output, of iron. The comment we received from this British steel company is that carbon in the stack is problematical but the general feeling at the present time is that carbon is a safe material to use in at least the bottom third of the furnace stack.

IRON TONNAGE ON CARBON HEARTHS

There are over 100 blast furnaces in this country with carbon hearths, partial or full. The figures available in 70 of these furnaces show a total of approximately 73,000,000 tons, or an average of over 1,000,000 tons per furnace.

An analysis of the tonnage figures is as follows:

4 blast furnaces with 2 million tons or more
12 blast furnaces with 1½ million tons or more
19 blast furnaces with 1 to 1½ million tons

—

Total 35 blast furnaces with 1 million tons or more.

A recent survey made by a joint committee of American Iron and Steel Institute on carbon hearths vs. ceramic hearths is of considerable interest.

This survey consisted of tabulating data on 61 furnaces with carbon hearths and then comparing this data with that on previous ceramic hearths in the same furnaces. A brief summary of this data is shown in Table II.

TABLE II

	Ceramic hearths	Carbon hearths
Number reported	71	61
Number of hearth breakouts	47	8**
Number of multiple breakouts	11*	1
Avg days per campaign	2240	Still operating
Maximum days per campaign	5342	Still operating
Minimum days per campaign	74	58
Breakouts per operating days	1 per 3003	1 per 10,074 (1 Jan. 52)

* These 11 multiple breakouts included 35 of the 47 listed above.

** 5 iron breakouts — 3 slag or cinder breakouts.

While the ratio of one breakout per 10,074 operating days for carbon hearths is quite impressive, let us not forget that one breakout was so serious that it was necessary to replace the entire hearth. In other furnaces that were blown out due to lack of business

there was considerable loss of carbon. In one of these furnaces the loss was of such magnitude that it was necessary to replace the outer ring of carbon blocks, as well as the entire tap hole area. The blocks in the bottom and those of the inner ring, excepting adjacent to the tap hole, were left intact. Since these repairs the furnace has produced almost a million tons of iron.

As previously mentioned, a breakout on a blast furnace is always of the utmost concern. It was very unfortunate that the industry had these two serious breakouts. However, it can now be said that much valuable information was gained from the experience of such costly breakouts.

Carbon is suitable as a refractory in the blast furnace. Two very important characteristics of carbon must always be taken into consideration. The first is its oxidation rate; the second is its high thermal conductivity. In the design and construction of a carbon hearth, proper engineering must always take into consideration these two factors. Proper consideration of the high thermal conductivity of carbon can be utilized to reduce its oxidation to a negligible amount.

Carbon has been added to the long list of improved refractory materials which is keeping pace with the continued demand of the steel industry for better materials to increase furnace life and decrease down time, as well as to decrease the safety hazard.

"REFRACTORIES FOR THE BASIC OPEN HEARTH FURNACE AND AUXILIARY EQUIPMENT"

By ERNEST B. SNYDER, Refractories Engineer
Wheeling Steel Corp.
Steubenville, Ohio

▲ WE are rapidly approaching a condition in steel plant operation where new and better refractories are required to assure that steel production moves forward in the future as it has in the past. The steel companies have a great stake in helping to develop new refractories.

The second job of the steel mill ceramic-man is to establish quality control methods on incoming refractory materials similar to those established by the metallurgist on the steel products. Some large companies have started this development, while others are relying on their mason and purchasing departments to obtain the best available refractories. The latter situation is undesirable, although no reflection on either of these departments is intended.

The basic open hearth furnace consumes the three major types of refractories—namely, clay, silica and basic—at a very rapid rate. Over half of the refractories used in a steel plant are consumed in the open hearth shop. The open hearth furnace with its auxiliary equipment is the best laboratory available in the steel plant for the testing of refractories, because the campaigns are relatively short and the refractories under test can be frequently observed in many locations. The service conditions are so severe that only a short time is usually required to show up inferior quality refractories. It may seem that a 200-ton open hearth furnace is an expensive test furnace. However, simulated service tests and laboratory tests, although helpful, are inadequate, and the final proof of a given refractory is a test panel or section in the furnace.

Although the cost of refractories plus the labor for rebuilding the furnace and auxiliary parts is an important factor in the cost per ton of ingots produced, too much emphasis is often placed on low refractory costs. Refractories are relatively cheap and should be effectively used rather than saved, because increased production will soon pay for increased total consumption. The ultimate aim is the production of a ton of ingots at the lowest possible cost. When a balance is reached between refractory costs, fuel costs and operating costs, the rate of production will be at its top economic limit. Initial refractory costs have been increased by the use of more high cost basic brick, but in many cases the increased cost has not been justified by increased life. However, increased furnace availability, higher operating temperatures and higher rates of production generally have more than compensated for the increased refractory costs.

An accurate study of refractory costs or performance cannot be made without considering all of the factors that affect the cost of producing a ton of ingots. Investigators and operators have been trying to reach the proper balance for many years. We have undoubtedly approached the perfect balance many times only to drift away from it for the want of reliable data to guide us. As an example, we might ask, "When is the economic time to replace checker brick?" For a given shop one definite checker life results in maximum economic production. Yet ten operators from that same shop may give ten different estimates of this period. We can also ask, "What is the value of furnace sealing and the effect of air infiltration?", and start a heated argument among any gathering of operators, fuel men and brickmasons. We lack sufficient precise data on which to base our decisions.

Flues—The only recent developments in refractories for flues is the use of high temperature concrete for arches and in some cases for the entire flue system. The largest factor in the success of concrete flues is the care used in preparing the concrete mix. Proper proportioning of the high temperature cement, the coarse and fine grog material, is very important. The material should be mixed adjacent to the job to prevent segregation. Substantial labor savings can be realized with this type of construction.

Checker Chambers—High duty clay brick are the common brick used in the checker roof. Superduty clay brick and semi-silica brick have increased the checker roof life in many open hearth shops. Flat arch suspended checker roofs have replaced many sprung arch

roofs. Sealing against air leakage has been aided, in the suspended roofs, by the use of refractory hangers so that insulation can be applied to the roof without burning the metal hangers. Thorough sealing of the walls and roof is very important in good furnace operation.

Checker Brick—The present preference for checker brick is a low porosity, high density product. Some checkers have been topped with silica and superduty clay brick. The glass industry has had fair success with basic brick where conditions were too severe for other types.

Fantail Arches—Fantail arches have always been expensive to maintain and difficult to keep airtight. The elimination of the double checker chamber for air and gas has allowed simplification of the fantail arch construction. Many shops have installed flat suspended arches with exceptionally good success. The quality of brick used may be high duty, superduty clay, semisilica or silica. Some installations have been made with plastic fire brick. Basic brick are usually used in the fantail nose in basic end furnaces.

Furnace Ends—The furnace ends above floor level were, until recent years, built entirely of silica brick. Extensive experiments have been carried out with the all basic end. Some shops prefer the basic end because of lower cost per ton and increased availability. Approximately 74 basic end furnaces are in operation today. Other shops have not been as sucessful with basic ends. They have found increased fuel consumption with little or no gain in tonnage or furnace availability. The higher fuel consumption probably can be traced to lower preheat temperatures, although no data are available at this time. The maximum benefits of an all basic end cannot be fully realized until an all basic roof is developed that will be economical. As soon as a basic brick is developed that will not peel or spall in service, the all basic furnace will become a reality and the basic end will become a necessity.

Furnace Body—The open hearth roof receives more attention than any other furnace part, probably out of proportion to its importance. The life of the open hearth roof does not appreciably affect the producing power or availability of the furnace. The roof can be replaced in a very short time as compared to the time required to replace other parts of the furnace. The labor cost per nine inch equivalent of brick is the lowest for installing a roof. Therefore, variations in campaign length, as governed by the wear on the main roof, do not materially affect the furnace availability or the cost of refractories per ton of steel.

In this country, until about 1945, regular silica brick were used in open hearth roofs, with the exception of a few isolated trials of a basic roof. As a result of Kraner's investigations, reported in 1944, on the effect of aluminum in silica brick, quality control was exercised on silica brick in most steel plants. Many roof failures that had been blamed on poor operation were explained. The superduty (low alumina) silica brick have given good service particularly when used as panels in areas of extremely heavy wear, but the definite improvements are difficult to evaluate. The first trial in almost every shop showed a marked improvement in roof life compared to regular brick. However, furnace men have a good habit of pushing their furnaces to the limit to obtain maximum production. After one or two campaigns, they discovered that the superduty brick would withstand higher temperatures. Therefore they increased the firing rates until the life of the superduty brick was cut to about the previous life of the regular brick. Their is little doubt that the benefit is therefore shown by increased open hearth production rather than by longer roof life. With silica roofs, a good grade of silica mortar is very important. Rapid roof joint wear results from the use of low refractory silica cements.

Some shops had not had time to evaluate the superduty silica brick before the zebra (alternate rings of basic and silica brick) roof began to show considerable promise. The zebra construction, like superduty silica brick, is usually used only in sections of extreme wear. The combination of basic and acid refractories is technically unsound because of possible chemical reaction. Apparently there is not enough liquid movement between the silica and basic brick rings to cause rapid wear. In the zebra construction the silica brick carry the load of the arch and appear to weld the basic brick in place and possibly modify the composition sufficiently to prevent the usual severe spalling of the basic brick. Returning the favor, the basic brick seem to shield the silica brick so that they do not wear as rapidly as if the roof were all silica. Replacement of common silica brick with superduty silica brick still further improved the life of the zebra sections and panels.

Basic Frontwalls and Backwalls—Basic brick frontwalls and backwalls have been used for years in most shops. The semisloping or full sloping backwall has eliminated most of the backwall troubles except for furnaces with rear flushing through the backwall. The frontwall still requires attention in most shops. The unfired, metal-encased magnesite-chrome brick give the best life if they are properly supported with steel plates braced to the buckstays. Extremely short frontwall life many times can be traced to insufficient foundation at the start of the campaign or underpinning because of poor frontwall maintenance practices. Improvements are needed to make a basic brick that will withstand the mechanical abuse of charging, and will have better resistance to slag attack and to the spalling that is characteristic of all basic brick. The frontwall is also the weakest link in the all basic furnace. Shutdowns for frontwall repair cause considerable damage to the basic roof.

Although the critical eye is usually focused on roof life and roof repair, the most important refractory section of the furnace is the hearth. The repair of the banks and bottom of the furnace requires more furnace time and costs more per ton of steel than any other section of the furnace. Most shops allow 30 to 40 minutes per heat for fettling time which is not shown as repair time; adding to this figure the repair time for severely cut banks or holes in the bottom, we find that in a shop making 10-hour heats, seven to eight per cent of the operating time is used for bottom or bank repairs. The cost of material alone can amount to from $0.50 to $0.70 per ton of steel. However, the material cost is minor compared to the cost of furnace time used for bottom maintenance.

Although many types of basic brick and ramming materials have been used, rammed bottoms on magnesite brick subhearths appear to be the most popular at the present time. A further modification is the rammed chrome subhearth with basic brick on top, finished with rammed main hearth. The advantage of the rammed hearth over the old burned-in grain magnesite hearth is the short time required for the installation. Some records show less bottom maintenance on burned-in hearths. However, the difference is not great enough to justify the extra time required to burn-in a deep hearth. Rammed hearths with high magnesia contents (over 90 per cent) are also being tried at the present time.

Hot Metal Mixers—The most economical mixer lining today is a combination lining with high duty clay brick in the area of least wear, such as roof, tank lining, and extreme bottom, with a combination of hard burned superduty clay brick and sillimanite (mullite) placed in the areas of extreme wear in such a way as to equalize the overall lining wear. Future developments in mixer linings probably will be in the nature of lower porosity, higher density products.

Steel Ladles—The common ladle brick, one of the lowest grade refractory brick available, still maintains its position as the best refractory for holding the hottest product in the steel plant. The ladle lining wears away very rapidly, giving a life of from 5 to 20 heats per four-in. lining.

"DEVELOPING THE USE OF COKE OVEN GAS IN THE OPEN HEARTH"

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▲ IN a modern steel plant with high tonnage rates, changes in practice can be considered only under extreme circumstances, such as changes in the material picture of the plant, or stiff competition with similar plants.

The policies set for this project for all practical purposes were the key to the results. The open hearth and fuel departments were told that within two years they "must" burn 70 per cent coke gas with no loss in production. The firing was to be done as an efficient fuel and not as a "dump" gas. Furthermore, with the reputation of coke gas producing foam, riding the roof, and producing a general headache, the job was to be done through development work and not surveying any other practice.

The research department broke the first ground and developed a high velocity flow nozzle for burning combinations of coke gas and liquid fuel. The next step was the development work in the field to make it practical. Had it not been for necessity, this phase would never have been completed. This involved developing a more practical burner, methods of handling new fuels in combination, instrumentation, and training personnel to swing, almost overnight, to a new type of furnace operation.

The steel industry faces, in the near future, the necessity of burning high sulphur oil. The use of high sulphur oil will mean higher flux burdens and loss in production. This project at Sparrows Point gives a practical answer for years to come. It was found that desulphurized coke oven gas in combination with tar is an ideal fuel, as both elements are low in sulphur and are derived from coal.

Upside Down Burner (Two Stream Burner, Type D) Burners tested are shown in Figure 1. It was finally decided that one practical way to avoid clogging of the gas pipe and excessive atomization of the liquid fuel would be to separate the liquid fuel and gas pipes. Furthermore, with gas at adequate pressure to provide a sufficiently high gas velocity at the burner tip it was found that the gas stream could be put above the liquid

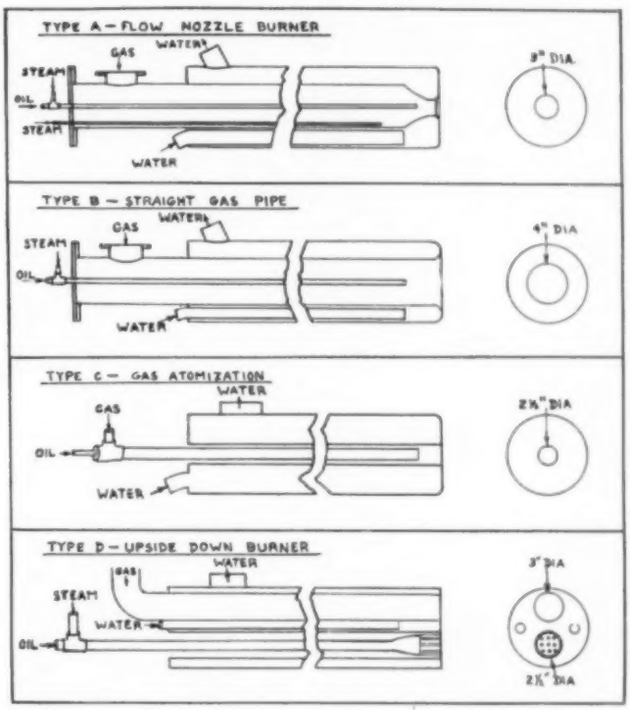

Figure 1 — The most satisfactory experimental combination coke oven gas and liquid fuel burner developed at the Sparrows Plant is that here shown as type D.

fuel stream. After several trials of various sizes and arrangements, a three in. gas pipe over a nine hole Fisher oil tip was found to give the best overall performance (Type D). This combination is now standard on all furnaces for combination coke gas and liquid fuel. Attempts have been made to go to larger gas pipes to cut gas compression costs and to smaller gas pipes to decrease burner cooler size, but in each case the performance was poorer. A larger gas pipe and a flow nozzle cannot be used in our case because of our limitations on burner cooler size.

Before definitely standardizing with the above burner, a few of the older helpers who had used gas at other plants wanted to try gas below the liquid fuel. The burners in their furnace were switched and the trial was made. At the end of two heats the experiment was stopped at their request. There was considerable foam, the furnace was burnt, and these heats took an hour longer. This applies, however, to 60 to 70 per cent coke gas.

The earlier work was done using oil-gas firing. It was found that 60 per cent coke gas could be used and give the same heat time as straight oil. With all the work being done to improve slag action for heat transfer, it was obvious to try tar from our coke ovens. Tar-gas firing gave about one hour better heat time and permitted the use of 70 per cent coke gas.

Experimental heats were made using raw coke gas containing about 450 grains of H_2S per 100 cu ft. The ladle sulphurs were 0.004 to 0.006 per cent higher than normal. During periods of high-sulphur iron, the ladle sulphurs and burnt lime consumption were completely out of line. Early in the experimental work, management decided to use desulphurized coke gas.

One gas desulphurizing unit has been put into operation. This desulphurizer uses hot actification, three to four per cent sodium carbonate, and has a capacity of 1,000,000 sq ft per hour. This unit will lower the sulphur in the gas from 400 to 50 grains of H_2S per 100 cu ft. The open hearth has been using 1,300,000 to 1,600,000 cu ft of coke gas per hr on 18 furnaces. Part of the gas must bypass the unit and give a blended gas of 150 to 200 grains of H_2S. At this level the open hearth has fuel of about the same sulphur content as with straight oil firing. The plans call for additional desulphurizers, and the eventual sulphur in the coke gas will be lower than good fuel oil. Using 70 per cent coke gas (50 grain) and 30 per cent tar (0.6 per cent S) the total fuel is equivalent to approximately 0.3 per cent sulphur oil.

Coke oven gas is used throughout the plant. Without a gas holder, the production and consumption must go hand in hand. From the standpoint of the plant, a constant amount on or off a furnace would have been the practical answer. However, this method would not permit the use of over 45,000 cu ft per hour per furnace, which amounted to only 35 to 40 per cent of the total fuel. The program called for the open hearth burning 70 per cent gas.

The present use of 70 per cent coke gas consists of varying the gas according to the period of the heat and averages 80,000 to 90,000 cu ft of gas per hour, per furnace. If the supply changes, two large reheating furnaces in the mills automatically change the combination of gas and oil according to the line pressure. When these "fly-wheels" are low in gas, one or more open hearth furnaces are taken off gas, and when there is excess gas they are put back on. The open hearth changes the number of furnaces on coke oven gas, but not the firing schedule posted on each furnace.

In developing the use of coke gas, it was found necessary to post firing schedules to show the furnace operators the plan to be followed. These schedules were used to develop the amount of liquid fuel to control slag action, and the remaining fuel as coke gas to support the temperature requirements of the furnace. A close follow-up on heat time, brickwork and general first pass checker conditions was also used to regulate these schedules.

In the early experiments with tar and gas, it was found that even with 70 per cent coke gas, checkers on the cool side (visual) clogged as quickly as when straight tar is used. It was also observed that when the first pass checkers appeared hot, the tar-gas deposits were dense, but did not melt. This condition gave good heat time over an extended campaign. These observations had to be checked as to the relation of fuel, temperature, and checker deposits to give the best zone of operation.

To establish why first pass checker conditions with tar and gas appeared different from straight oil, it was necessary to collect samples of checker deposits and check them as follows:

1. Classify physical appearance according to fuel and operating temperatures.
2. Chemical analysis and fusion points.
3. Run fluxing tests with checker brick and various deposits.

In burning high percentages of coke gas with liquid fuels and, at times, straight liquid fuel there have been many instrumentation problems to solve. It was found necessary to use a gas instrument which was fully compensated for changes in line pressure and temperatures. With liquid fuel, the problem arose from trying to control at 100 to 200 gphr on an instrument designed for 600 gal. These problems, as well as many others, were solved by our fuel department.

SUMMARY

With management setting the destination and direction to take, and the team obtaining the necessary facts, the change to firing high percentages of coke gas in the open hearth without loss in production was accomplished. Fortunately, the results were even better, and production increased.

The more important technical features are:

1. This project developed a practical method for burning high percentages of coke gas in the open hearth. The low radiating fuel is at the top of the flame and the high radiating fuel is next to the bath. The liquid fuel controls bath action for heat transfer. The coke gas supplies the remaining heat requirements for the furnace proper and air preheat.

2. The lower alkali checker deposits of tar-gas firing permit higher checker temperatures and, therefore, higher air preheat.

3. The relation of heat time, air preheat, and checker deposits with different fuels is important. Any fuel change requires knowing this relationship.

4. The scheduling of fuels during the various periods of the heat and constant follow-up were necessary for converting to new fuels and are still necessary to maintain efficient firing.

5. Coke gas can no longer be considered an inferior fuel. Desulphurized coke gas, supplied at the right pressure and used properly with a small amount of tar, gives an ideal open hearth fuel, from coal alone. The plants with enough coke ovens have an answer to the high sulphur oil problems predicted for the future.

Safety Analyses--

AN AID TO ON-THE-JOB INSTRUCTION

. . . . this paper was presented at the 18th Annual Philadelphia Regional Safety and Fire Conference and Exhibit, March 5, 1952 at a session sponsored by the Philadelphia Section of the AISE . . . .

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▲ OVER the past several years, observation of the application of Job Safety Analysis in many phases of steel making, and a careful analysis of the results achieved, bring the firm conviction that it warrants a prominent place in any accident prevention program. Whether you call it J.S.A., Job Breakdown, Job Safety Study or by any other name matters but little, for the procedure as well as the objective is very much the same. It is an analytical approach to the accident prevention problem, involving the study of each job step by step, listing the potential hazards involved, and involving a practical recommendation for the recognition, elimination or reduction of each hazard. It is a long range program which, to be successful, must be carried out by the foreman in co-operation with the worker. It is a medium for individualized, personalized job study and instruction. Although introduced as a tool of safety, it has in many instances resulted in more efficient and economical operation. It is a basic program which all other programs must stem. Unfortunately, however, it is subject to the pitfalls of any particular program, which means that it can be successful only if properly introduced, intelligently applied and diligently followed up.

Job Safety Analysis is by no means a new approach to the accident prevention problem. It has been practiced in many industries over a period of years. The foreman who, before starting a job, studies the job in detail, discusses it with his workers and issues the necessary job safety instructions, is to a degree performing a J.S.A. The main difference is that, in the past, our J.S.A.'s were confined mostly to major jobs and the procedure was not submitted in writing. Consequently, many of our jobs were not covered by Job Safety Analyses.

There are a number of reasons for our new approach. First, it is important to study all jobs. If we stop to think for a moment, it will be realized that major, or planned jobs, rarely produce accidents. It is the small job, the repetitive job, which usually accounts for the bulk of our injuries. Why not then consider these jobs in the same light as the major jobs? Foremen may comment: "The job is so simple that it does not warrant such attention," or "We have always done the job this way and haven't had any trouble yet." Still another comeback is, "It would take years to analyze all the jobs that my men do." In reply, it can only be said that no job too large, too small or too simple for the application of J.S.A., and again, it is the simple jobs and the things that appear to be of little consequence that get us into most of our difficulties. The fact that a job has been done in a certain way for years without having had an accident is certainly no proof that it is being done in the best manner, nor that we will continue to be so fortunate. As to the statement that it may take years to cover the jobs in some departments, we can go just one step further and say that the job will never be finished. This may sound a little rough on the surface. In effect we are handing the foreman a lifetime assignment. But is it rough? In respect to production, have we the right to feel that after a month, a year or two years, we will no longer have to exert any effort to keep production rolling? Of course not. Well then, if we accept safety as an integral part of production (and we most certainly should), how can we expect to coast on our safety job after any given period of time?

We first have the problem of performing the J.S.A. Errors will be made which will necessitate doing some

of them over. In other instances we will find J.S.A.'s inadequate, calling for further study. Changes in production methods and plant layout will occasion further consideration. True, if we approach the job in the right manner it will after a time require less and less effort, the same as when we lay a good foundation for production activities, but the job will always be with us.

There are many advantages in preparing the J.S.A. in writing. If the foreman writes the J.S.A., he is likely to make a more detailed study of the job. J.S.A.'s performed by different foremen on similar types of jobs can then be compared, and the best features of each incorporated into one master J.S.A. It establishes a written procedure for doing a job, which can be used to instruct present workers as well as new personnel. It also contributes to uniformity of job performance. Last but not least, it serves as an educational program for both foremen and workmen.

In many respects there is little difference between performing a J.S.A. and a thorough accident investigation. When investigating an accident we trace the movements of the injured, solicit the opinion of his co-workers, and carefully examine all machinery and equipment involved. Anything that might have had a bearing on the accident, such as weather or illumination, must be considered. Subsequent study of the information thus accumulated is helpful in determining what steps should be taken to prevent a recurrence. The conclusion may indicate that one or a number of factors contributed to the accident. It may have resulted from an unsafe act on the part of the victim or a co-worker. This may mean lack of adequate work procedures, ignorance on the part of the injured that work procedures existed, a failure to fully understand, or a deliberate violation of existing procedures. It may indicate that the injured failed to wear available personal protective devices, or that we have failed to recommend the use of such devices. It may indicate an unsafe condition, one that has existed for a long period of time without having been recognized, or one that was recently created and had not been observed or had not received prompt attention. Regardless of the cause, thorough investigation of an accident usually exposes the things that were wrong, making possible a solution to the problem. In addition, we many times bring to light accident-producing factors which have not necessarily had any bearing on the current accident, but which could be conducive to other types of accidents in the future. Job Safety Analysis is conducted very much along the same lines, and will produce the same results, and more. The advantage lies in the fact that the study is usually made before the accident has occurred, not afterwards.

In applying J.S.A., attention should be directed to those jobs or occupations which are responsible for the bulk of injuries. By so doing it is possible to achieve a maximum reduction of injuries in a minimum period of time. In order to accomplish this, it is advisable to analyze the accident experience of each department, taking into consideration not only the disabling injuries but the minor injuries as well. Such a study will develop how, where and to whom injuries are occurring, thereby establishing the initial targets for our efforts.

The success of this program, as well as any other program, depends very much on how well it is presented to the foreman. It should be made clear that this job cannot be accomplished over night, that it is a long-range program. He should be told that even 15 or 20 minutes a day devoted to the program, can accomplish much, provided this time is devoted each and every day. He must be instructed not to try to analyze the overall duties of a worker, such as a laborer, but to consider one of his jobs at a time, such as bundling rod or removing scale from a pit. He must be told to list the steps of the job in the order in which they occur, and to record all details, however unimportant they may seem. He must be cautioned not to write up the job as he thinks it should be done, but as it is actually being done at the time of the observation. He must be firmly impressed with the importance of discussing the job with the worker during the period of analysis, and of using the final, approved J.S.A. for the purpose of instructing present as well as new employees. He must also understand that a follow-up procedure is very essential, as some employees, accustomed to doing their jobs in a certain fashion, will be inclined through force of habit to revert to their accustomed procedure rather than follow the new one.

When the foreman has been properly indoctrinated along the lines just mentioned, he is ready to launch his program. It is advisable to first concentrate on a few of the simpler jobs in order to become familiar with the procedure. Before attempting any job however, the worker should be advised of the program. He should know that it is a safety study, that his opinions and suggestions are welcome, and what the program is designed to accomplish. This usally tends to create a favorable impression on the worker, a feeling that the foreman is interested in his personal welfare, and that he is considered a member of the team.

If during the observation, the foreman should note a step of the job being carried out in what he considers an unsafe manner, he should first list the hazard involved and then discuss the matter with the worker. This discussion should not be of a critical nature, but with a view of arriving at a joint solution of the problem. If the foreman conducts himself properly, it will not only influence the worker to do that particular job safely, but will have a definite bearing on forming the habit of working safely which, of course, is our ultimate objective.

After the J.S.A. has been written, checked and approved, it should become the standard procedure for performing a particular job. There are many ways in which the J.S.A. can be used effectively. In the case of present workers, the J.S.A. should be gone over step by step, on the job, with each man. It is not enough to merely explain the new procedure. Reasons for changes in the method of operation should be explained as well. It must be realized that a certain worker might have been doing his particular job in the wrong manner for a long period of time. To be successful in changing his methods, we must show him why these changes are advantageous.

The J.S.A. can also be effectively applied to new employees. It should be used in teaching him how to do his job, step by step. As each step is explained it should be demonstrated as well, and the hazards of not per-

forming the job as prescribed should be called to his attention. J.S.A. does not necessarily eliminate all job hazards, but properly performed it at least brings them to light. Naturally, there are certain inherent hazards in connection with every job. Recognition of such hazards will reduce the probability of accidents.

J.S.A. can also be used advantageously as the basis for short standup meetings with the workers. In these meetings it is wise to concentrate on violations of procedure which are more generally observed. Bringing such violations to light, and giving the worker an opportunity to present his opinion might develop an answer to this problem. It may indicate that certain steps of the procedure are impractical, calling for further study and revision.

In discussing this subject, it was not the intention to create the impression that performing a J.S.A. and going over it once with the worker will bring an end to all accidents. It may be necessary to instruct some individuals only once. Others may have to be told time and again before results are obtained. In addition, we must make them understand, and the job is not finished until we are certain that they do understand.

As in any other program, a follow-up system is highly essential. Frequent observation of employees performing their jobs can be very beneficial. If the worker does not do his job as prescribed it can be traced to one of the following reasons:

1. The procedure established is impractical.
2. The procedure has not been properly explained.
3. The worker has failed to understand.
4. The worker has not been impressed with the importance of following the procedure.

Regardless which of these reasons apply, we must first examine ourselves before being critical of the worker. In many cases, failure on the part of the worker to conform to proper work procedure can be traced to a failure in the administration of the program.

We believe that uniform methods of job performance, establishing the habit to work safely and individualized, personalized job instruction can be best accomplished through the medium of Job Safety Analysis as an aid to on the job instruction.

SAMPLE ANALYSES

Earlier, it was mentioned that it is advisable for the foreman to select a few simple jobs at the beginning of his program, in order to become familiar with the procedure.

Table I covers the manufacture of stopper rods. This is also a relatively simple job, but capable of producing injuries. Unless covered by J.S.A., many of the small hazards of this job might easily remain hidden, only to be exposed one by one as injuries occur.

Table II covers removal of scrap from hog wallows. During the first 8 months of 1951, we experienced 7 minor and 2 disabling injuries in connection with removing scrap from hog wallows at our blast furnaces. The method used was to place the crane hook under the scrap, raise it sufficiently high to place a bar beneath the scrap and then wrap the chain around the scrap and remove it. On occasion, the scrap would break, fall on the bar and cause the bar to fly upward, striking the operator in the face. A J.S.A. developed the idea of burning holes in an eye beam and placing the beam beside the wallow. A bar could then be run through one of the holes and in the event that the scrap fell and struck the bar, the bar would be prevented from flying upward.

The rod and wire mill had experienced a number of serious injuries, including amputations, in connection with the operation of overhead electric hand hoists. The up and down movement of the load is governed by a button control on the bottom of the handle and men often had their hands or fingers caught between the load and button control due to the load swinging. Education of operators improved our accident experience, but we still continued to have injuries. A second J.S.A. was performed, the result of which indicated the advisability of redesigning the hoist handle. Since this change has been made, accidents of this nature have been totally eliminated.

In past years a number of injuries, one of which was a fatal, occurred to operators working on our bethanizing frames. The blocks on these frames are necessarily long, making it necessary for the operator to place himself between blocks on certain occasions. In so doing, we have had men caught and revolved around the block. Every effort was made to educate workers and to create an awareness of the inherent hazard of this job. Several J.S.A.'s were performed but the results were not entirely satisfactory. A further study of the job resulted in developing additional safety devices. A bar was placed above the floor beneath each block so that if a man was caught his body would strike the bar and shut down the entire frame. Previously, a cord extended along the side of the frame so that it could be pulled by the operator in the event that he got into difficulty. These cords were removed and a bar extended away from the frame for the same purpose. These devices have only recently been installed and refinements will most likely be made, but it is at least a step in the right direction.

The J.S.A. was designed as a tool of safety, but had in many cases, resulted in a more economical operation. As an excellent example of this fact, the electrical department experienced a number of injuries during the course of changing batteries in tractors and lift trucks. A J.S.A. was performed which resulted in a decided improvement in their accident experience, however, workers continued to sustain injuries, a number of them serious, while changing batteries on a 16,000-lb tractor. A study was made on this specific unit, disclosing that most of the accidents occurred during the act of either removing or replacing the removable sides of the battery compartment. These side plates weigh about 85 lb and the lower end is designed to seat into a recess on the body of the tractor. In attempting to replace the sides, it was found that they would sometimes fail to seat properly and fall striking the workers' feet or legs. The tractor battery compartment was redesigned and the removable sides eliminated. This not only eliminated the injuries, but in addition resulted in a 30 per cent saving in time in changing batteries, which is an important factor in view of the fact that some units require as many as two battery changes per turn.

TABLE I

Job Safety Analysis

Department: Open Hearth Pits
Name of Operation: Manufacture of Stopper Rods

December 23, 1949

Steps: Write down the steps in the order in which they occur.	Unsafe procedures: List for each step the unsafe procedure that exists in connection with each step.	Recommendations: List for each unsafe procedure what steps can be taken to promote safer procedures.
1. Transporting rods from pit to bench.	Strained backs. Pinch points.	Assume proper lifting position. Two men work as team and keep hands clear of pinch points. Avoid undue haste.
2. Remove stopper heads from barrels.	Scratching hands on protruding nails.	Remove all nails from tops of barrels before taking out heads.
3. Attach stopper heads to rods.	Striking fingers.	Keep hand tools in good working condition.
4. Loading sleeve brick from stockpile to wheelbarrow.	Stock pile collapsing, brick rolling or falling from stock pile on man.	Remove brick evenly from stock pile to avoid pyramiding or undermining.
5. Wheeling brick from stock pile to stopper rod bench.	Wheelbarrow overturning and throwing man or falling on him.	Load evenly, balance load, refrain from overloading. Have route area clean and free from debris or obstacles. Clear right of way.
6. Handling brick placing sleeves on rod.	Cutting hands on burrs or sharp edges. Pinching hands or fingers.	Advise wearing gloves in good condition. Work methodically and carefully to avoid pinch points and undue haste.
7. Mudding up sleeve brick joints. Wiping excess mud from joints.	Cuts from sharp edges and burrs.	Wear rubber gloves.
8. Rolling rods into oven.	Pinch points and possible back injury.	Work as team and avoid undue haste. Use three men to roll rods on top shelf.

TABLE II

Job Safety Analysis

Department: Blast Furnace Cast House
Name of Operation: Pulling Hog Wallow R. E. Crews, Blower

Date: January 31, 1951

Steps: Write down the steps in the order in which they occur.	Hazards: Unsafe acts and/or condition. List all unsafe acts that exist in connection with each step.	Recommendations: List for all unsafe acts or conditions what steps can be made to correct them.
1. Crane operator goes up steps to overhead crane.	Danger of slipping on steps.	Use hand rails as provided.
2. Crane operator puts in the switch—pushes in control button to operate crane.	Danger of brakes and hoist limit not working or danger of controls not being on center.	Check all controls to see if they are off. Test foot brake and hoist limit before starting to operate.
3. Bring crane to hog wallow and lower crane chain to men on cast house floor.	Danger of striking men on the floor with the chain.	Crane operator should not bring crane over the men until signaled to do so.
4. Ground men hook chain hook under edge or end of hog wallow scrap.	Danger of men stepping in hot iron or getting hot sand in their shoes.	Men should not step down in or over hot runs or hog wallow.
5. Crane operator raises scrap high enough to place long bar under the piece of scrap.	Danger of scrap slipping off chain hook. Danger of hog wallow scrap breaking and burning men if any molten metal is inside.	Men should step back until they see the chain is going to hold and hog wallow scrap is cooled enough to pull.
6. Men then place long bar through hole in steel beam and under scrap. Men then hook chain around scrap.	Danger of scrap breaking and slipping and small particles striking men in face or on body.	Man must place bar through hole in steel beam and then slide the bar under the piece of scrap.
7. Crane operator then hoists scrap in air taking same to scrap car.	Danger of crane traveling over men on the cast house floor. Danger of men working on tracks. Danger of scrap breaking or molten metal.	Cast house men should step in the clear before giving the crane operator the signal to hoist the scrap. Operator should ring bell while passing over floor and cars.

Many more examples could be given. The black plate assorting department of our Tin Mill was having a high frequency of injuries. J.S.A.'s were performed and a 75 per cent reduction in injuries resulted during the first 2 months after the J.S.A.'s were used on the job. Our galvanizing department in the pipe mill had shown a progressive increase in dispensary cases for the years 1948, 49 and 50, some of these injuries being of a serious or disabling nature. During 1951, Job Safety Analyses were performed on 75 per cent of the jobs in the galvanizing shop. At the end of last year, the records showed that there had been a decrease of 51 per cent in injuries during 1951 over the previous year, with no serious or disabling injuries.

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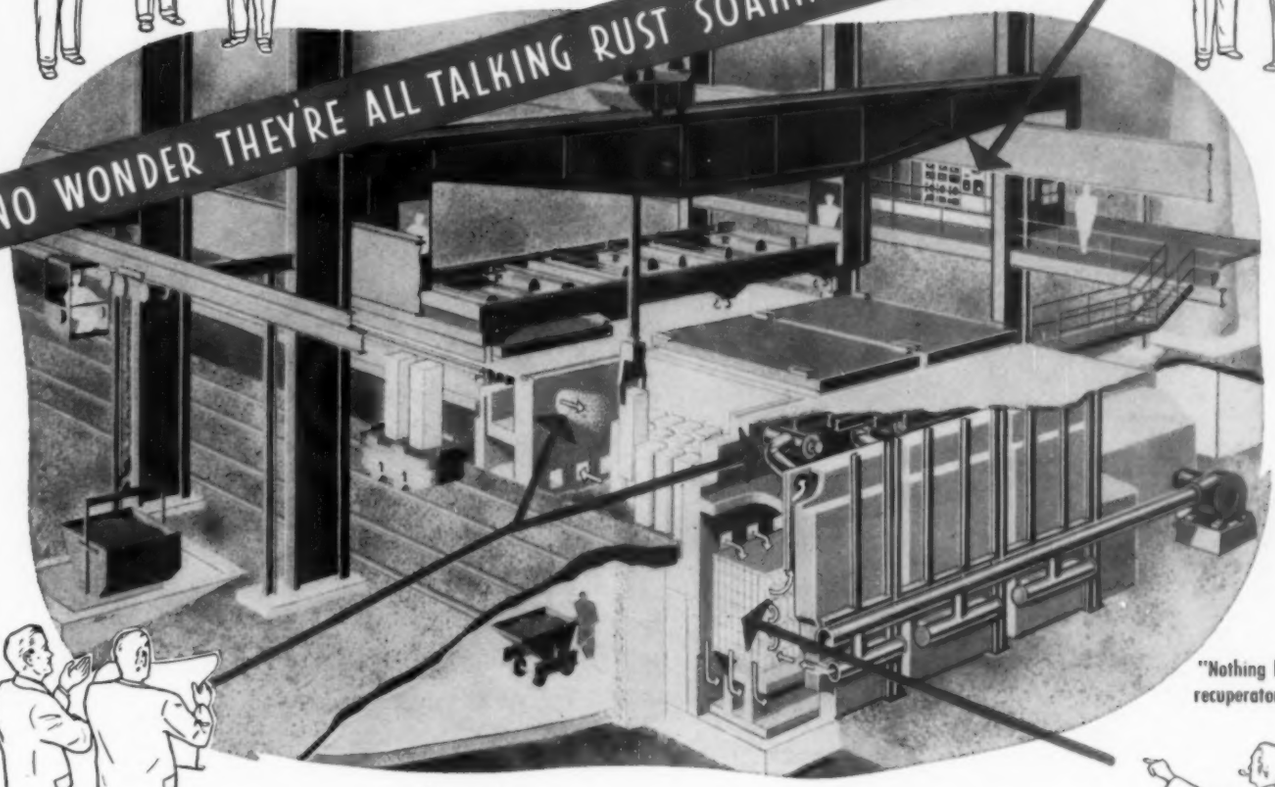

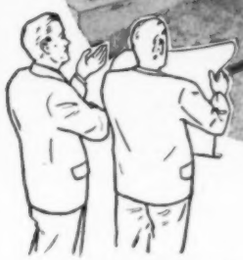

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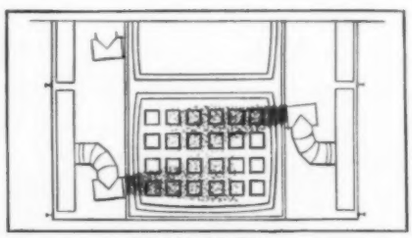
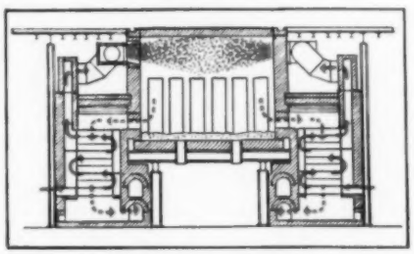
raise the standard for outstanding results



PLAN VIEW



CROSS SECTION

Naturally, furnace men are impressed with the improvements provided by Rust's new ultra modern recuperative soaking pits. Heat is uniformly balanced by diagonal two-way firing and ingots soak out evenly. Absence of impingement increases life of refractory walls and covers. Design permits construction in batteries of two or more holes, use of all fuels.

Rust also builds regenerative type soaking pits of new modern design. Those now in operation are producing results in fuel economy and heating speed never before achieved.

Whether you are interested in new recuperative or regenerative soaking pits, or require a modernization job you can rely on Rust. Over a quarter-century of experience is your guarantee.

THE WHOLE JOB IS ONE JOB WITH A "RUST PACKAGE CONTRACT"

One contract covers everything . . . from blue-print through start up. Rust assumes responsibility for design, manufacture, erection, and is prepared to undertake all phases of the work with its own forces, including wiring and piping. This results in substantial savings . . . One profit instead of pyramiding ones which accrue where many subs are employed.

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Pioneers in Furnace Design

PITTSBURGH - PENNSYLVANIA

F-

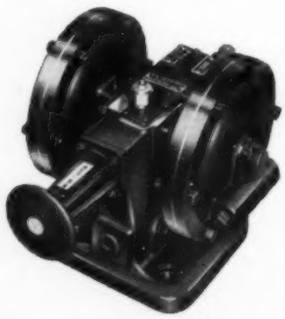
A PANEL OF EXPERTS
for Soaking Pit Control

This Askania panel is one of six at a Chicago district mill, each one controlling the operation of a four-hole soaking pit battery. Just as on hundreds of other pits across the country, these controls are doing the Askania job—helping to make more and better steel for less.

SIMPLE AND COMPLETE This is a typical straightforward Askania control system. It includes fuel-air ratio, pit pressure, and flue suction controls. These are what the pit operator needs to help him get the same good results in heat after heat.

FUEL-AIR RATIO CONTROL The heart of this system is the Askania Fuel-Air Ratio Regulator. It gives high accuracy over a wide range of firing rates. It meters the fuel flow and provides just the right amount of air for combustion. This means uniformly good scale formation and fuel economy.

In the Askania Fuel-Air Ratio Regulator, the forces that represent fuel flow and air flow are physically balanced against each other. This simple arrangement means dependable accuracy over turndowns of 10 to 1, where the actual signal turndown is 100 to 1. Hydraulic operation and the Jet Pipe Principle mean long life, easy maintenance, and plenty of power.



FREE BOOK ON SOAKING PIT CONTROL— Write for Bulletin 116, "Askania Controls for Soaking Pits." It tells how various elements in the control system affect quality of steel and cost of steelmaking.

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GREFCO BASIC BRICK For All Industry

The metallurgical industry demanded furnace linings capable of withstanding extremely high temperatures under extraordinary operating conditions. To meet this challenge, Grefco research produced the famous RITEX unburned basic brick—one of the outstanding advances in the entire history of brick manufacture. RITEX brick possess great accuracy to specified dimensions. They are more resistant to thermal spalling . . . offer lower porosity, lower thermal conductivity, and higher hot strength. These properties insure increased service at reduced cost.

STEELKLAD For Tough Duty

For service too tough even for RITEX, Grefco offers STEELKLAD, an unburned basic brick, permanently jacketed in a patented steel shell. The brick will not slide from its shell in the construction of a furnace wall. When the furnace is heated the steel oxidizes and is absorbed by the brick. It provides an exceptionally efficient monolithic lining that outlasts all other brick in basic open-hearth steel furnaces, electric-arc furnaces, soaking pits, copper smelting and refining furnaces, and other basic metallurgical furnaces.

Take A Look At STEELKLAD

Shown below is a typical STEELKLAD basic brick, steel-jacketed on the four major faces, and containing Grefco's unburned magnesite-chrome brick. The brick itself is exclusive and patented—as is the permanent steel shell. It may mean major savings in your operation. Write, wire or phone General Refractories in Philadelphia—or contact your nearest dealer.

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WHATEVER YOU BUY—IT'S BECAUSE OF BRICK!
Refractory brick, the only product capable of lining the furnaces that produce the silver, nickel and copper for our coins—the paper for our dollar bills. And, most everything we buy with our money also owes its origin, in part, to refractory brick.

SUCH REFRACTORY BRICK AS RITEX AND STEELKLAD popular basic brick made by General Refractories Company for virtually all metallurgical furnaces. These leading favorites are exceptionally capable of resisting destructive forces—providing long life at high temperatures.

66 GREFCO MINES AND MANUFACTURING PLANTS, here and overseas—together with 18 sales offices, hundreds of distributing agencies, and the most modern of research facilities—deliver a truly *complete refractories service.*

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WORLD PRODUCTION RECORD

on Triple-Action Presses

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Adjustable-voltage by the Reliance V★S System has answered the challenge of establishing and maintaining record production from mammoth, triple-action automobile body presses at Ford Motor Company's new Buffalo Stamping Plant. Flywheel and clutch are eliminated. Starting, stopping and reversing are accomplished electrically. Adjustable inching speed is available as required from direct-connected, 500-horsepower Reliance motors—the largest ever placed on such presses. Other important advantages of these drives by Reliance include the saving of a substantial amount of steel that was formerly scrapped and a reduction in die replacement costs. Contact your nearest Reliance Sales Representative for further facts on drives engineered by Reliance—for presses or any other type of production machinery.

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New BLISS Reversing Mill becomes Greer Steel's "Workhorse"

It takes a rugged, versatile mill to maintain exacting standards for quality of finish and accuracy of gauge on short runs and quick changeovers. A new Bliss 4-high reversing mill, specially designed to meet "job-shop" requirements, was the answer for the Greer Steel Company, Dover, Ohio.

The new Bliss mill has oversized sections to take severe usage. It has material-handling aids and precision controls for quick and safe changeovers. Already known as "the Greer workhorse," because it handles practically all the heavy draught work at Greer, the Bliss mill rolls carbon and alloy steels in all tempers. Reductions of 25% on the first pass are not unusual. Metal thicknesses are reduced as much as 90% and finish gauges as thin as .005". Tolerances at times are held within .001". Mill speed regularly exceeds the rated 1000 fpm.

Greer also likes its new Bliss mill because every practical feature for its universal usage is built in. This includes a back-up roll changer (concealed in floor when not in use), coil box, roll breaker, expanding mandrels and sticker guides.

Bliss rolling mill engineers can meet your special requirements, too. Write for further information.

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A NEW, COMPLETE SYSTEM OFFERING HIGH CURRENT CAPACITY AND LOW IMPEDANCE

Keystone introduces a new development—an aluminum conductor (third rail) system. In addition to conserving critical copper and steel, it offers industrial users many important operating and structural advantages. Here is a complete sliding contact system which is pre-engineered, efficient and compact in design, yet constructed for years of service. It has high current-carrying capacity . . . up to 1,000 amperes . . . with a small cross-sectional area.

Non-magnetic, the new Keystone Aluminum third rail system provides good voltage regulation for alternating current because of its low impedance. It offers new economies because it is easier to install, requires less manpower and eliminates the need for high-cost supporting structures.

It is designed for such applications as main crane runways, bridge conductors, hydro-electric dams and numerous other jobs.

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BABCOCK & WILCOX INSTALLS NEW FORMING EQUIPMENT

▲ AS a part of its $30,000,000 expansion program, The Babcock & Wilcox Co. has installed at its Barberton, Ohio, plant a new vertical press and a horizontal draw bench for producing hollow forgings and for bending heavy plate.

The vertical hydraulic press (Figure 1), which was built practically in its entirety in the Barberton shops of the company's Boiler Division, has a normal operating capacity of 6500 tons or an intensified capacity of 8500 tons. The operating pressure is 3000 psi and it has an operating stroke of 9 ft 6 in.

The three main cylinders, which are 45 in. in diam are weldments as are the bottom, movable, and top platens which weigh 130, 200 and 115 tons respectively. The cast iron rams are 43½ in. in diam. Columns, 26 in. in diam and 52 ft long, are located on 16 ft centers across the face and 14 ft centers fore and aft. Two 12 in. diam balancing cylinders are provided as well as two 12 in. diam pull-back cylinders.

Located on the press center and in the pit below the bottom platen is a 500-ton ram 22 in. in diam with a 54-in. stroke which has been provided to pierce a manhole in drum heads. This ram is fitted with two return cylinders. The bushing used for piercing is fitted with an ejector ram with an 8 ft 6 in. stroke actuated by an 11¼-in. bore cylinder.

Operation with high pressure on only the center cylinder, or on only the two outside cylinders, or on the three cylinders concurrently, has been provided for so that a choice of approximately 2100, 4400, or 6500 tons is available on the down-stroke.

When functioning as a piercing press, the heated ingot is loaded into the bushing and the stripping plate installed while the piercing pot is positioned on a shifting table 14 ft from the center of the press. The loaded pot is then moved into work position by the shifting table which is moved by a 14 ft stroke ram actuated by a 9 in. bore cylinder in one direction and two 6¼ in. bore cylinders in the opposite direction. The maximum size ingot that can be handled is 26,000 lb. Subsequent to the piercing cycle, the shifting table returns the piercing pot to its former position where the ejection cylinder functions to unload the workpiece. Actuation of the shifting table, the ejector cylinder and also the 500-ton pit ram is by push button control.

When the press is utilized for forming drum-shell plates to a predetermined radius, the piercing pot is moved by the shifting table to a position at the rear of the work area of the press. This leaves an unobstructed space between press columns for the entry of the hydraulically operated plate manipulator from its loading position to its work position under the moving platen.

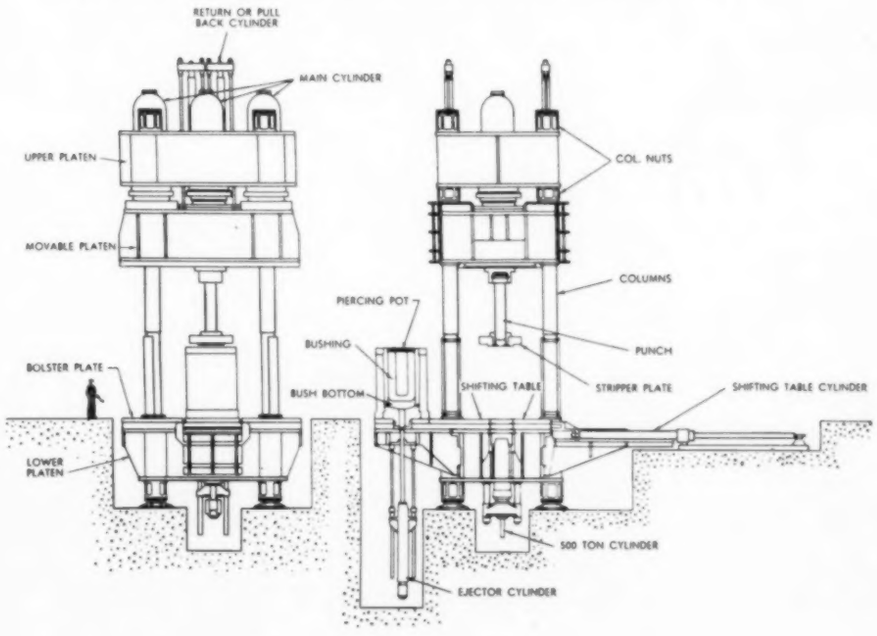
This plate manipulator, which comprises the 42-ft long lower bending beam, also forms the carriage for cross-travel through the press. It also houses the 16-in. bore hydraulic cylinder which actuates the 52-ft stroke ram which moves the carriage. Storage space for the top bending beam has also been provided for in the design of the unit. The assembled weight of the plate manipulator is approximately 350 tons.

At each corner of the carriage is a hydraulically operated manipulator consisting of a vertical, trunnion-mounted cylinder which actuates 6 ft 10 in. stroke rams designed to handle 35 tons. This permits handling a 50-ton plate with any two manipulators.

The cylinders for each unit are mounted on a carriage that moves in contact with the side of the lower bending beam and also with rails located in the foundation. The carriages are adjustable longitudinally so that they can be spaced from 8 ft to 42 ft apart to handle plates of varying lengths. Angular tilt of the manipulators of approximately 20 degrees from vertical is accomplished with cross cylinders located on the carriage.

All motions in connection with the manipulator are hydraulically controlled. Movement is instituted by electric push buttons which energize solenoids which in turn actuate air

Figure 1 — This newly constructed vertical press has a normal operating capacity of 6500 tons and an intensified capacity of 8500 tons.



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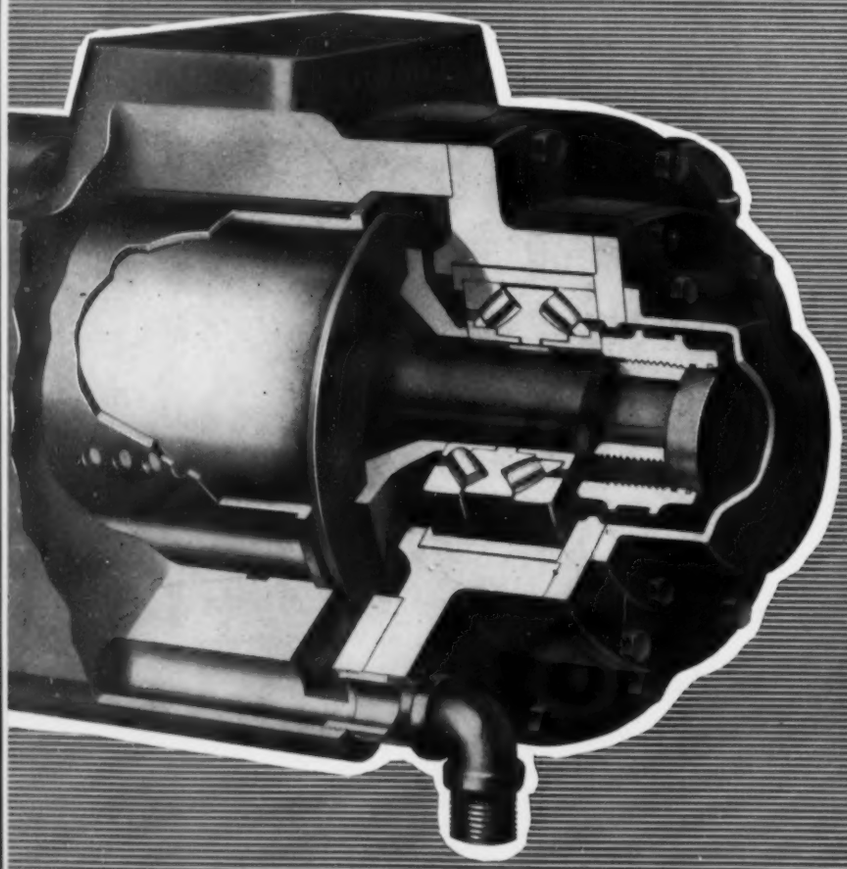

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MB-21

pilots on the hydraulic pressure lines. There are six panel-type push button control stations, multiplied together and strategically located, so that one operator can position the workpiece on the lower bending beam, move it to work position in the press, and also start the forming cycle on the press. The entire control system is safeguarded with interlocks.

The procedure for forming plates is to cold press in their entirety plates up to about 2¾ in. in thickness. Heavier plates are first rough formed while at forging temperature, then finished after they have cooled to room temperature. The same set of dies are used for both cold and hot forming. Plates 42 ft in length can be worked.

The new horizontal draw bench (Figure 2) is utilized for forming hollow forgings from ingots previously pierced on the vertical press. The draw bench has a 1200-ton rating. The return stroke is operated at 600 tons and pressures of either 600 or 1200 tons can be selected for the forward stroke, which is 30 ft in length. No other such equipment exists in America today.

The unit has an overall length of 114 ft and a main cylinder with a 32 in. bore. The main plunger, which is an inside packed piston-type, is 22½ in. in diam. The columns on the draw bench are 16 in. diam with a total length of 84 ft. The die bed is 31 ft 6 in. long with location for die holders along 28 ft of its length. The unit is equipped with a swivel type die holder and also 7 roller supports. These roller supports, which position the mandrel and workpiece, are hydraulically operated with a 25 in. adjustment. They are actually small hydraulic presses, push button operated, and can be shifted lengthwise along the draw bench as required.

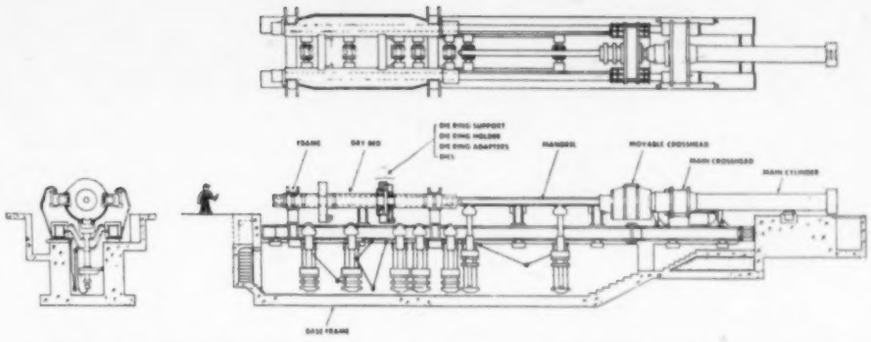


Figure 2 — After the ingots are pierced on the vertical press, a new horizontal draw bench is used to form hollow forgings.

The hydropneumatic pressure system, for operating both the press and the draw bench, is powered by three triple-piston, single stage pumps, each geared to a 500-hp, 2300-v synchronous motor. Each pump has a delivery rate of 234 gpm at 3000 psi pressure. The large high pressure storage capacity required is provided by an accumulator plant of two water bottles and five air bottles of the company's normal banded vessel construction. A lubricant is used in the water to prevent oxidation of the working parts.

Automatic operation of the pumps is accomplished with a high and low level control. A sequencing device permits alternate operation of the three pumps.

The hydropneumatic power equipment is located in an addition to the company's main power plant. The vertical press, the draw bench, and the heating furnaces are housed in a new building which is 92 ft high, 105 ft wide and 275 ft long. This shop is served by a 100-ton overhead travelling crane.

The auxiliary equipment, including the machine tools, hydraulic test equipment and special press tools, are to be located in an adjoining building now under construction which is 80 ft wide, 325 ft long and 64 ft high.

The new equipment will produce seamless hollow forgings from a minimum of 8 in. inside diam and ¾-in. wall thickness up to a maximum inside diam of 26 in. and a wall thickness of 4½ in. in lengths up to 22 ft. The maximum weight of the cropped ingot which the equipment can handle, 26,000 lb, controls the maximum final size of the forging which may be 14 to 15 ft in length for heavy wall thickness and large diameters, and up to 22 ft in length for lighter wall forgings.

Figure 3 — Heavy plate is formed into a boiler drum section on the new vertical press.

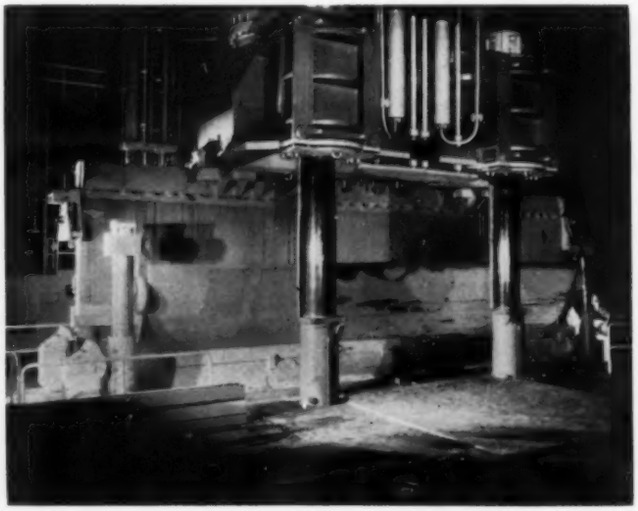
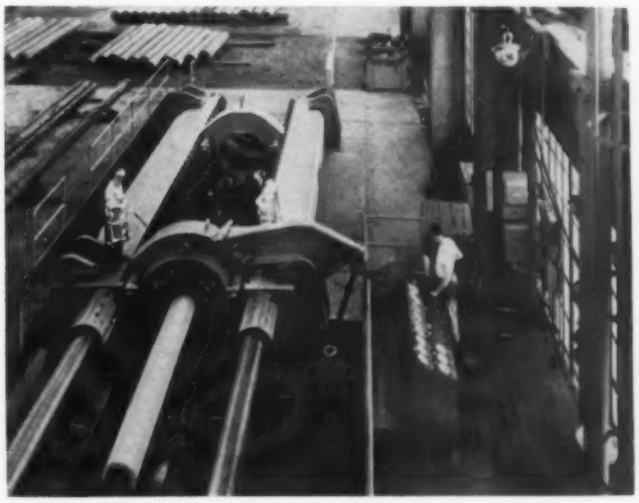


Figure 4 — On the horizontal draw bench, the pierced ingot (left foreground) is forced by the mandrel through a series of ring dies to produce hollow forgings.



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CHEMISTRY APPLIED TO MAINTENANCE CLEANING PROBLEMS

Dowell Service cleaned *TWO* in 24 hours!

A hard, porous silicate deposit, ⅛ to ¼ of an inch thick, had formed on the tubes of two 100 HP waste heat boilers in a large steel plant. Much of this deposit had sloughed off and become cemented together until in many places the annular space between the tubes was completely filled. Steam production was too low.

Dowell Service cleaned both boilers in 24 hours. An inspection of the tubes showed that all deposits had been satisfactorily removed. Steam production was greatly increased. The operator was pleased with the job and has used Dowell Service twice since for maintenance cleaning of the same equipment.

Maintenance engineers in industrial plants throughout the country have found that Dowell Service can provide *fast, effective and economical* cleaning of boilers, condensers, heat exchangers, water lines and other equipment. Special liquid solvents, designed to dissolve and disintegrate costly, profit-stealing deposits, are pumped into the equipment, reaching surfaces inaccessible to other cleaning methods. The entire job is finished in a matter of hours, without dismantling.

There is a place in your maintenance program for Dowell Service. Experienced engineers will be glad to consult with you on your particular problem. Call Dowell now.

Other recent Dowell jobs:

Gas Washer cleaned in 4 hours without cutting water to sprays during cleaning. Result: Pressure drop across washer reduced from 20.25″ to 6.75″.

•

Dust catcher cleaned in 13 hours without dismantling. Result: Prior to Dowell Service, catcher dumped 5 tons; after, 30 to 35 tons per day.

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Production from two water wells in a small manufacturing plant had declined because of deposits clogging the producing formation and screens. Dowell Service increased the water flow 300%.

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Date-line Diary...

July 2

▲ The Treasury announced the Government ran up a deficit of $4,017,000,000 for the fiscal year ending June 30, and spending totaled $66,146,000,000 in the 1951-52 period.

▲ Copperweld Steel Co.'s division at Warren, Ohio reached an agreement with the CIO Steelworkers on the basis of a modified union shop. An interim agreement was attained between Harrisburg Steel Corp. and the union.

July 3

▲ Following its settlement one week ago with the CIO Steelworkers on the basis of a modified union shop, Pittsburgh Steel Co. petitioned the Government for price increases of $3.00 a ton under the Capehart Amendment.

July 5

▲ Benjamin Aaron, vice chairman of the Wage Stabilization Board, estimated that under the new economic controls law wage curbs will be ended for approximately 7,000,000 employees.

July 7

▲ Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has arranged with a group of insurance companies for a loan amounting to $75,000,000, part of which will be used to complete the company's expansion program.

▲ The Defense Production Administration awarded 324 certificates of necessity on $315,700,000 of new or expanded defense facilities during the week ending June 19.

▲ According to the AISI, the operating rate of the steel industry is scheduled to be 14.8 per cent of capacity for the week beginning July 7, and this is equivalent to 307,000 tons of ingots and steel for castings, compared with 277,000 tons (revised) one week ago.

July 8

▲ American Chain & Cable Co. reached an agreement with the CIO Steelworkers, which provides for a 12½¢ hourly wage increase, plus fringe benefits and a modified union shop.

July 9

▲ Commerce Department reported total employment reached a new high in June of 62,572,000 or 750,000 above June of 1951.

▲ New domestic freight car deliveries in June totaled 6411 compared with 6857 in May, the decrease is due in part to steel strike. Orders in June totaled 3264, and as of July 1 backlog of cars on order was 99,615.

▲ Aluminum Co. of America and the International Council of Aluminum Workers Unions, AFL, announced completion of negotiations for a five year interim agreement covering 9500 workers at six of the Alcoa plants. This gives a 10 per cent general wage increase, and a continuation of the maintenance of membership clause. It also contains a cost-of-living escalator clause.

July 10

▲ NPA directed Weirton Steel Co. to shift its entire output of tinplate to canner-quality suitable for packing perishables.

July 11

▲ President Truman signed a bill giving $46,500,000,000 for the military.

July 12

▲ Commerce Department reports U. S. exports in May were the highest in history with a total of $1,461,000,000. Imports were $834,800,000.

▲ Plans were announced for a merger of U. S. Pipe and Foundry Co. with Sloss-Sheffield Steel & Iron Co. U. S. Pipe now owns 54.8 per cent of Sloss-Sheffield.

▲ The Air Force is spending $4,500,000 for a new rolling mill at Alcoa's Davenport, Ia. works. Mill will produce tapered aluminum sheet and plate up to 10 ft wide and 33 ft long.

July 14

▲ The AISI reports that operating rate of the steel industry beginning July 14 is scheduled at 15.1 per cent of capacity. This is equivalent to 314,000 tons compared with a revised figure of 295,000 tons (14.2 per cent) one week ago.

July 15

▲ Aluminum Association reports a new monthly high in May when 161,607,096 lb of primary aluminum were produced.

July 17

▲ Alcoa asked the government for a 2¢ a lb price boost for pig aluminum and 10 per cent for fabricated metal.

July 18

▲ Interior Department reports U. S. coal exports in the first six months of 1952 were 30,000,000 tons, a 16 per cent increase over the previous year.

▲ Bethlehem Steel Co. plans to spend $10,000,000 to improve its Lake Erie docks at the Lackawanna Plant.

▲ Commerce Department reports that corporations paid $3,800,000,000 in cash dividends in the first six months of 1952. This is a 5 per cent increase over a year ago.

July 19

▲ Ward's Automotive Reports announced that auto production this week fell to the lowest figure since early 1946. Total units were 22,025.

July 20

▲ F. W. Dodge Corp. reports that construction in the first six months of 1952 fell behind record 1951 with a total of $7,758,578,000, in the thirty-seven states east of the Rockies. The June figure was $1,488,850,000.

July 21

▲ AISI reports that the operating rate of the steel industry for the week beginning July 31 is scheduled at 15.3 per cent of capacity. This is equivalent to 318,000 tons of steel compared with 316,000 tons (revised — 15.2 per cent) last week.

July 22

▲ E. I. duPont de Nemours reported sales for the first six months of $759,000,000 slightly under the previous year. Net profits were $2.12 a share.

July 23

▲ Sheffield Steel Co. asked for price increases ranging from $4.00 to $13.00 a ton.

▲ U. S. Steel and United Steelworkers of America set up an agreement extending employee insurance coverage through the month of August in case the strike continues into August.

▲ DPA set seven new expansion goals. Iron ore will be raised 57,000,000 gr tons to 147,000,000 gr tons by 1955. Manganese would go to 2,500,000 gr tons by 1954, an increase of 630,000 tons over 1950. Program calls for six additional ore carriers on the Great Lakes, increasing electrolytic tinplate from 1950 capacity of 2,800,000 to 4,100,000 short tons in 1955, and doubling the continuous galvanized sheet and strip capacity to 1,300,000 short tons by 1954.

July 24

▲ John L. Lewis served notice that he is terminating his agreement with the soft coal producers in 60 days. Unless a new contract is signed, agreement expires September 20.

▲ Kaiser Steel Corp. applied to OPS for price boosts averaging $9.68 a ton.

▲ Westinghouse Electric Corp. announced sales for the first half of 1952 set new records with $681,378,000. Net income was $31,507,000 or $1.95 a share.

▲ Allis-Chalmers Mfg. Co. announced record billings for the first six months of $267,141,887. Net income after taxes totaled $11,510,307 or $4.05 a share. Backlog on June 30 had increased slightly and totaled $218,085,585.

▲ General Electric Co. reports sales for the first six months of $1,171,202,000, slightly under one year ago. Net profit totaled $57,119,000 or $1.98 per share.

▲ President Truman announced that the six largest steel producers and the CIO Steelworkers had reached an agreement on important basic issues and that the steel strike was over. This announcement followed a meeting between B. F. Fairless and Phillip Murray at the White House. Included in the agreement was a modified union shop and an average wage increase of about 16¢ an hour. Steel prices are expected to rise an average of $5.20 a ton.

▲ Steelworkers formally called off their strike today after a meeting of the wage policy committee.

July 25

▲ AISC reports June bookings of fabricated steel total 167,492 tons, a decrease of 20 per cent from the previous month. Shipments for June fell because of the strike to 125,486 tons. The backlog on June 30 was 2,261,503 tons.

July 28

▲ Du Pont made an agreement with the government to produce an additional 13,500 short tons of titanium sponge during the next five years. The government will advance the company $14,700,000.

▲ Armco Steel Corp. reported net earnings for the first six months of $14,565,386 or $2.79 a share compared with $3.93 a share one year ago. Total sales were $256,799,787 for the same period.

July 29

▲ Alcoa reached an agreement with the CIO Steelworkers which is understood to follow closely the steel settlement.

▲ Jones & Laughlin Steel Corp. announced increases for the salaried employees of about 10 per cent of the base rate.

▲ Tory government in Great Britain announced details of a steel denationalization plan which will return the industry to private ownership, although still keeping government control over raw material, production and prices.

▲ U. S. Steel Corp. announced a dividend of 75¢ a share on common stock and $1.75 per share on the preferred stock. Because of the strike the usual financial report has been delayed.

▲ Lukens Steel Co. reports net income for the first three-quarters of its 1952 fiscal year which ends July 5 of $1,697,543 after income taxes. This is equivalent to $5.34 a share compared with $10.66 a share for the same period in the previous year. Net sales totaled $51,096,682.

▲ The AISI reports that production of steel this week was scheduled to rise to 45.4 per cent of capacity. This is equivalent to 943,000 tons compared with last week's actual output of 317,000 tons (15.3 per cent).

July 30

▲ The Wage Stabilization Board passed out of existence and a new board went into operation today, whose powers have been sharply limited by Congress.

▲ Inland Steel Co. reported net income for the first half of 1952 of $11,345,060 or $2.32 a share compared with $3.57 a share for the same period in 1951. Total sales for the six months were $218,175,335.

▲ Alcoa reported total sales for the first six months of $276,509,472 and net income after taxes of $22,688,570. This is equivalent to $4.39 a share after preferred dividends.

▲ OPS approved a raise in Missouri and Texas brown iron ore prices of about 85¢ a ton.

▲ Reynolds Metal Co. started expansion at its Listerhill, Ala. plant where $1,500,000 will be spent for a new merchant mill.

July 31

▲ Bethlehem Steel Co. reported net profits for the first six months of $2.19 a share compared with $4.74 a share for same period in 1951. Total billings were $806,785,149 and profit after taxes and other allowances were $24,304,730.

▲ Crucible Steel Co. signed an interim agreement with the CIO Steelworkers.

▲ Negotiations between the Wheeling Steel Corp. and Lukens Steel Co. with the CIO Steelworkers were broken.

July 31

▲ The government lifted its sixteen month ban on private imports of tin effective August 1.

▲ Granite City Steel Co. reported net sales for the first six months of 1952 at $31,597,771. Net income was $1,380,194 or 82¢ a share, compared with $2.27 a share one year ago.

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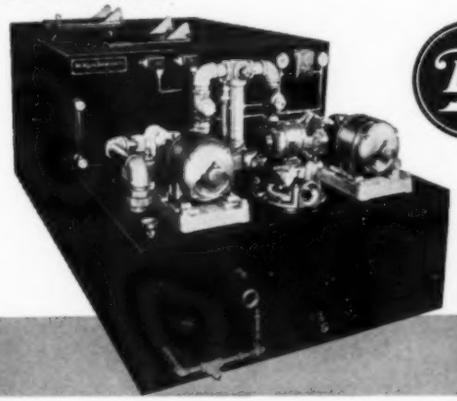

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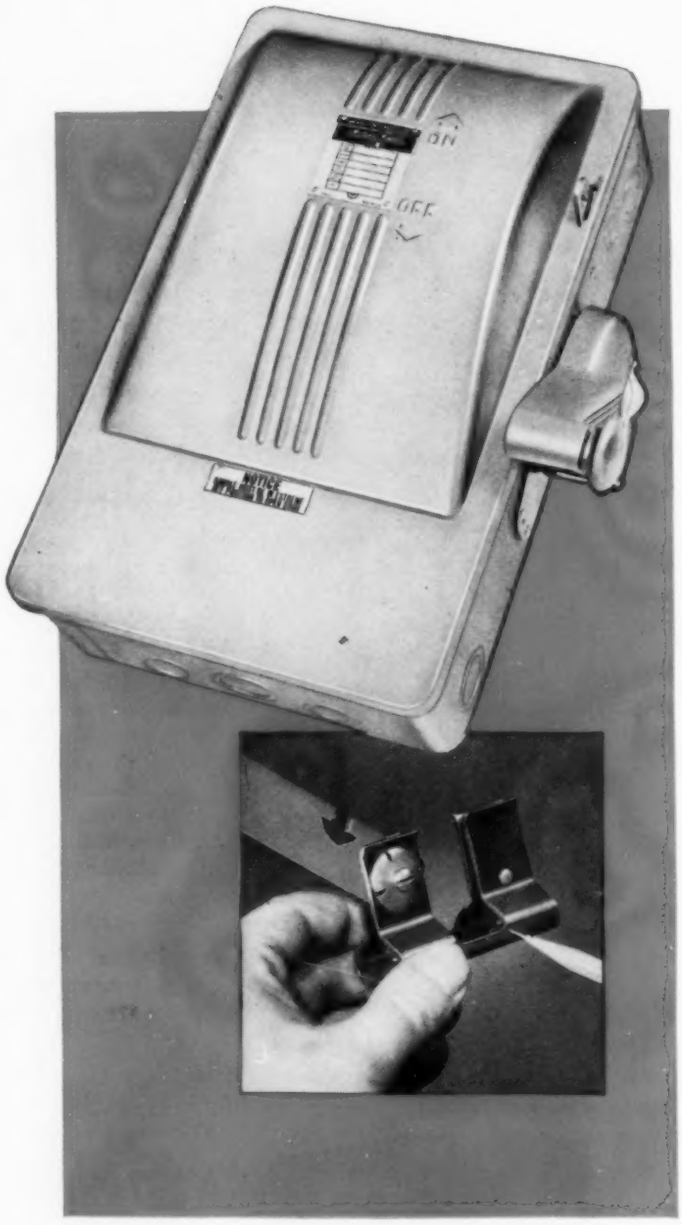

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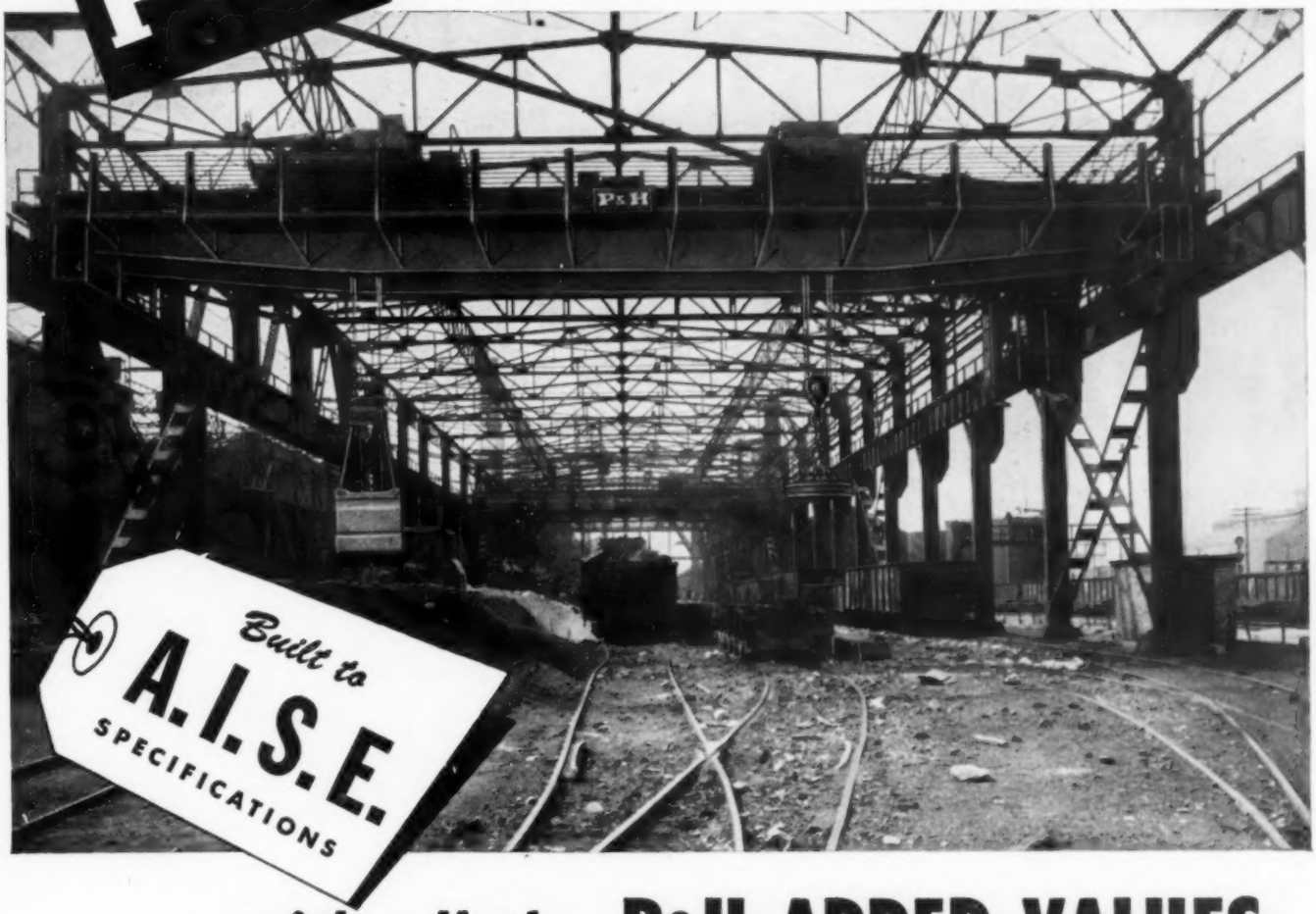

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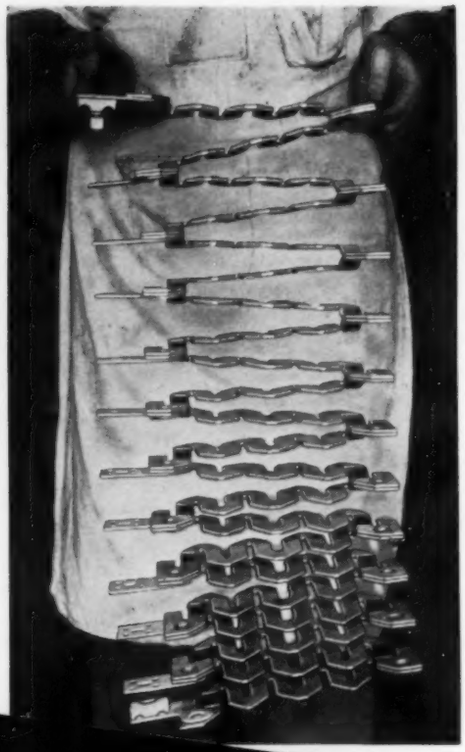

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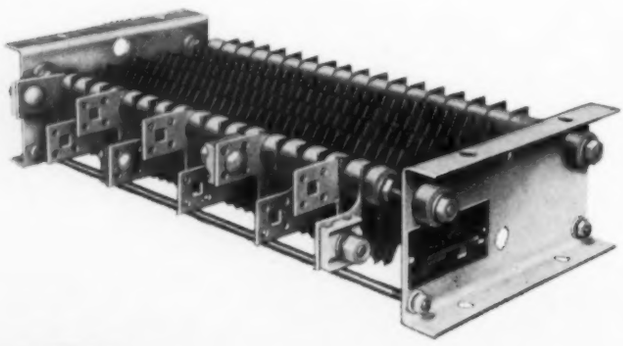
E&M TAB-WELD PLATE RESISTOR

PATENT NO. 2,378,054

Resistors get little attention, because they are usually mounted overhead or in similar hard-to-reach locations. Clamping-nut pressure slackens under alternate heating and cooling. Formerly, under the reduced pressure, OHMIC value changed, burning occurred and often was *not* noticed until damage took its toll.

But—note how resistor troubles are now eliminated in the EC&M TAB-WELD design! The current-carrying path is continuous—and is *independent* of end clamping-nut pressure. Convenient tap-plates simplify tap-shifting—make possible small adjustments in resistance value, because plates are closely spaced. Also, these alloy-steel resistors are corrosion-resisting—and have negligible resistance-change between cold and maximum working temperatures.



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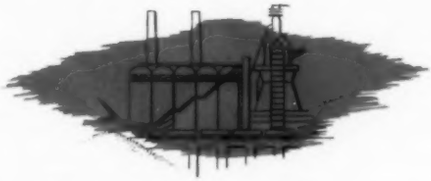

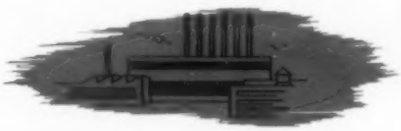

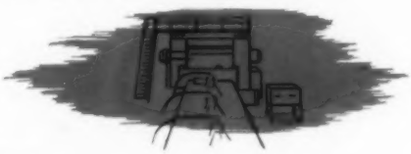

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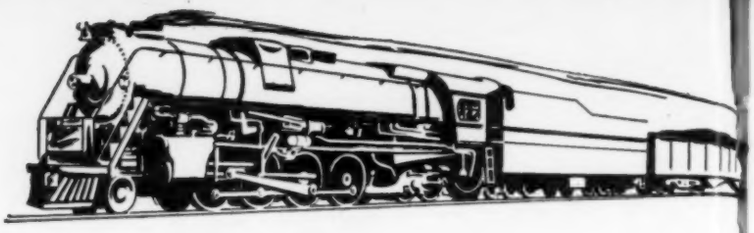

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Industry News...

NEW MERCHANT PIG IRON SOURCE TO BE MADE AVAILABLE IN MICHIGAN

▲ A new source of merchant pig iron in Michigan will be available early in 1954 according to an announcement by Frank J. McLaughlin, president, Michigan Iron & Coke Co. This new Michigan firm is starting construction work on a blast furnace and coke oven installation on a large site 2½ miles south of St. Clair, Mich., some 45 miles north-east of Detroit, on the St. Clair River. When completed, the plant will be capable of producing 300,000 tons of merchant pig iron and 350,000 tons of coke annually, and will employ 250 to 300 workers.

At the present time, virtually all pig iron produced in the Detroit area is used in the production of steel. Pig iron for the large automobile production foundries and many large and small jobbing foundries in the Michigan area has been imported from various parts of the United States outside of Michigan and from foreign countries such as Belgium, Germany, etc., at much higher than going American prices.

Raw materials for the new blast furnace will be delivered principally by boat. Construction is being started on a new boat slip capable of unloading simultaneously two large lake freighters carrying iron ore, coal, limestone or scrap metal. These materials will be delivered by conveyor belts from unloading hoppers on dock areas to the adjacent blast furnace and coke ovens.

The new plant is located next to the new St. Clair power station of the Detroit Edison Co., which will be the largest of that company's five generating plants.

Ability to deliver all raw materials by water or to use nearby rail or highway facilities, if necessary, should result in a low cost operation that will be a benefit to all foundries in Michigan. Expansion either to the west or to the south is possible on the large tract of land.

The new plant will be equipped with the latest devices for catching flue dust, etc. Water discharging into the St. Clair River will meet all of the Michigan stream pollution requirements.

It is estimated the new plant will cost in the neighborhood of 25 million or 30 million dollars, and the company will be privately financed. A certificate of necessity has been received from NPA providing for accelerated amortization and release to the company of the necessary materials required in the construction of the plant.

Present officers of the company are: Frank J. McLaughlin, O. P. Ashurst, and Frank J. Donovan. The board of directors consists of: Frank J. McLaughlin, Calvin Bentley, Carl W. Johnson, H. Kirk White, Don R. Mitchell and O. P. Ashurst. Temporary offices of the Michigan Iron & Coke Co. will be at 2707 Book Tower, Detroit 26, Mich.

BRITISH STUDY AMERICAN STEEL MAKING METHODS

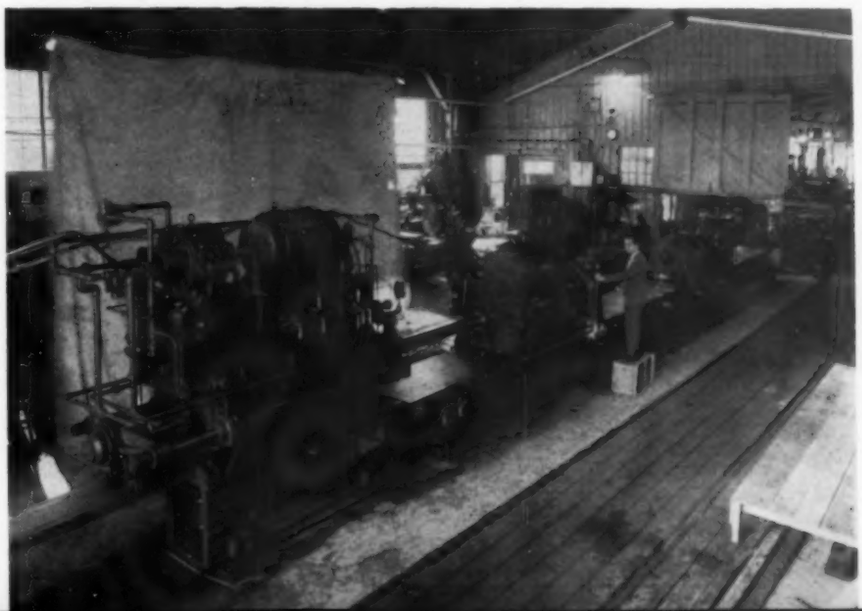
▲ American methods will prove of great value to the British Steel industry's 5-year development plan, says a report just issued by the British Iron and Steel Federation. The report summarizes findings of a British technical team which visited U. S. steel plants.

SUTTON DEVELOPS NEW STRETCHER

Demonstrated recently to engineers and operators of the steel and aluminum industries was this 100-ton hydraulic stretcher, built by Sutton Engineering Co., Bellefonte, Pa. The hydraulically powered head stock carries a motor-operated detwisting head. Oil-hydraulic power is supplied to the 96 sq in. piston at pressures of 2000-2500 psi by a motor-driven rotary pump mounted on the top of the main operating cylinder.

The tail stock is moved along the bedplate by a motor drive, and is anchored in place by a large pin which moves down into holes in the bedplate.

The material to be straightened is held in the head and tail stocks by pneumatically operated four-jaw clamps. The combination of twisting and stretching can cure almost any kink, twist or camber in metal bars of any section within limits of the machine power. The cold working inherent in the stretching action also results in changed physical characteristics in a degree dependent on the amount of elongation. It is further believed that the machine will have considerable application in the reclamation of sections that may be slightly larger than tolerance limits permit.



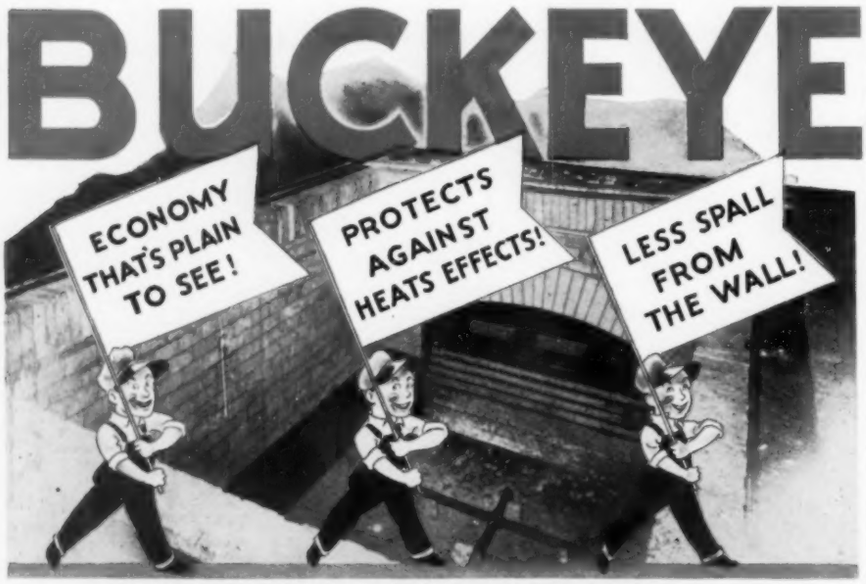
Meanwhile, a new blast furnace, the biggest in Britain has just gone into operation at Margam, Wales, alongside the giant Margam steel plant which is partly equipped with American machinery. The furnace has a hearth diameter of 25 ft 9 in., and is capable of producing 1,000 tons of iron daily.

Britain's steel plan calls for steel output capacity to be raised from the present 16 million ingot tons to 20 million tons annually by 1957. A 50 per cent increase is slated for pig iron capacity, from 10 to 15 millions tons.

New sources of ore supply are to be developed, particularly in Africa.

Extensive capital investment is seen for new coke furnaces, blast and open hearth furnaces, and for rolling mills.

The industry's first 5-year development plan, started in 1946, has already increased output per man of finished steel by 25 per cent. The need for even further increases in steel output is mainly due to the rearmament program, which has made it necessary for Britain to import one million tons of finished steel from the U. S. this year.



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BUCKEYE
"FOR THAT EXTRA SERVICE"
SILICA FIRESTONE

FAIRLESS FURNACES TO USE PRECIPITATORS

▲ Nine open hearth steel making furnaces now being built at U. S. Steel's Fairless plant at Morrisville, Pa., by Koppers Co. Inc., will be equipped so that smoke usually rolling from the stacks of these furnaces will be largely eliminated.

Elimination will be accomplished by Koppers-Elex electrostatic precipitators, a pair of which will be installed at each furnace. Electrostatic precipitators treat the furnace smoke electrically, causing the dust in it to be removed to collecting hoppers for disposal.

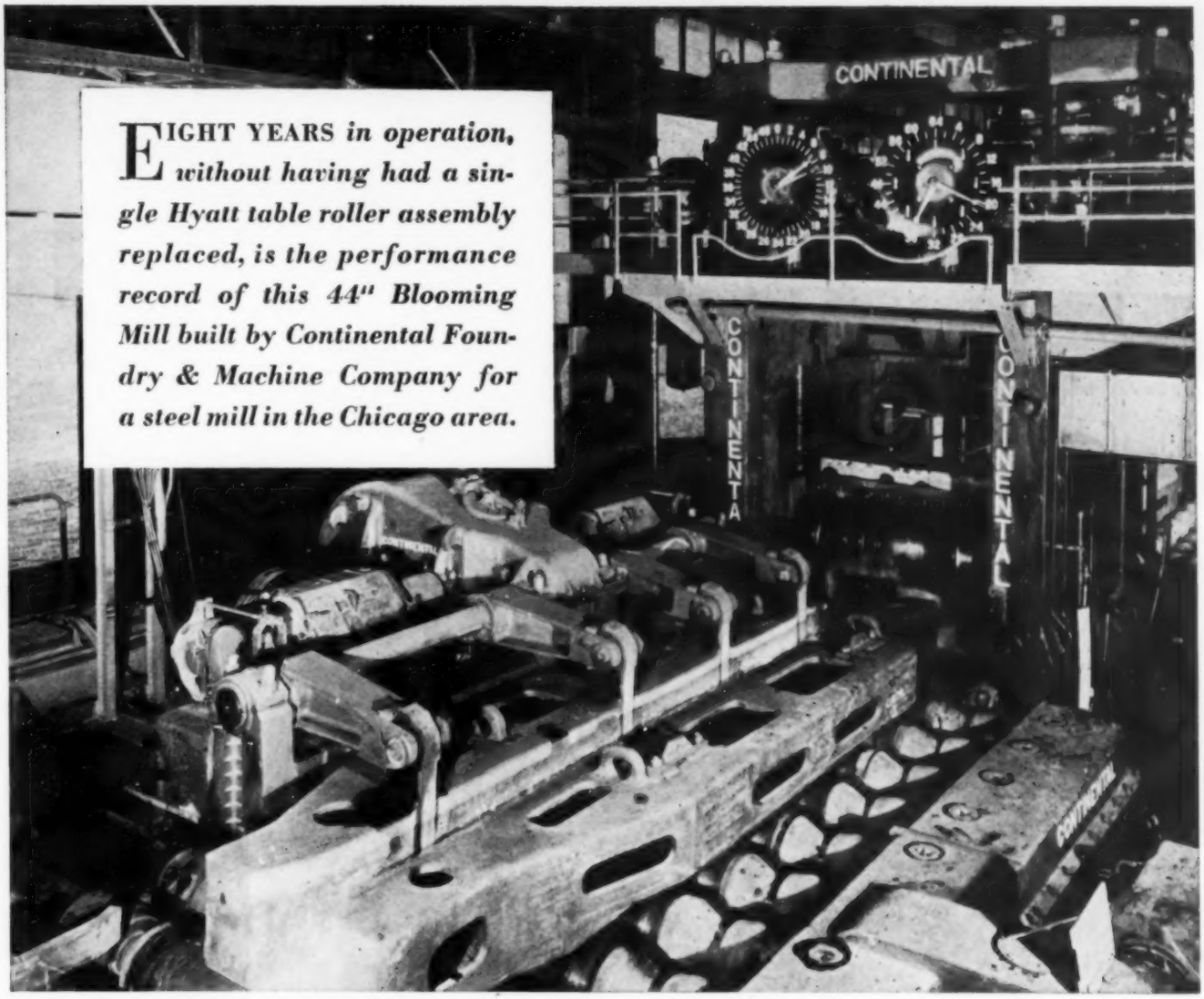
The precipitators are being installed as integrated parts of the open hearth structure, and are located immediately beside, and in a line parallel to the furnaces, in the system of flues between the furnaces and their stacks or chimneys. Each pair of electrostatic precipitators will be about 48 ft long by 38 ft wide by 38 ft high. The twin arrangement makes possible the bypassing of one of a pair for maintenance purposes.

Electrical energy necessary to operate the precipitators will be provided by 27 Koppers-designed packaged power units, three for each of the nine pairs of precipitators. These packaged power units energize the precipitators with direct current at about 65,000 volts.

Fairless plant's open hearth precipitator installation will be the second of its kind in the country, the first having been made about two years ago on the West Coast. Fairless is unique, however, as the first installation in the East and the largest anywhere. The precipitators are designed to remove more than 95 per cent of the dust normally in the open hearth exhausts.

ESTABLISH FELLOWSHIP AT MELLON INSTITUTE

▲ A fellowship for conducting systematic studies of standardization and its applications in science, engineering, production and marketing has been announced by Dr. Edward R. Weidlein, president, Mellon Insti-



***EIGHT YEARS** in operation, without having had a single Hyatt table roller assembly replaced, is the performance record of this 44" Blooming Mill built by Continental Foundry & Machine Company for a steel mill in the Chicago area.*

HYATT Preference Earned by Performance

In steel mill tables, cranes, cars and mill motors, designs are such that the loads taken by antifriction bearings are predominately radial.

The simplest, most direct way to lay in bearings to take radial loads is to design with radial bearings. Straight cylindrical bearings provide maximum load-carrying capacity for a given space because no radial capacity is sacrificed to absorb thrust through the rollers.

Since radial bearings are a natural for so many steel mill applications it is no wonder that Hyatt Roller Bearings, with such a complete line, are the preferred bearings. A wide range of available sizes and types insures the selection of just the right bearing for each application.

Specify Hyatts for your new equipment or changeovers and take advantage of the high capacity, long life, resistance to shock loads and provision for axial shaft expansion that Hyatt Roller Bearings provide. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

AMERICAN CHEMICAL PAINT COMPANY
AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet
Subject: IMPROVED DRAWING AND COLD FORMING WITH GRANODRAW

INTRODUCTION:

When steel is phosphate coated with "Granodraw" prior to working it, drawing, extrusion, and other cold forming operations are greatly improved. In fact, the protective phosphate coating makes the cold extrusion of steel possible.

Getting cold steel to flow depends on the unique properties of this coating. Its non-metallic phosphate crystals are physically and chemically adapted to acquire a strongly adsorbed lubricant. The combination of adherent phosphate coating and adsorbed lubricating film possesses a low coefficient of friction while maintaining its integrity under extremely high deforming pressures.

The drawing of wire and many other cold forming operations — including the cold extrusion of steel — are greatly facilitated by the application of a "Granodraw" phosphate coating and a suitable lubricant prior to working.

"GRANODRAW" DATA

"Granodraw" zinc phosphate coating chemical is applied to pickled surfaces in an immersion or spray process. When used with a suitable lubricant, the coating reduces friction under conditions of low, medium, or high deforming forces encountered in such typical operations as: cold extrusion of steel; cold shaping; deep drawing (tubs, cartridge cases, shells, etc.); stamping; drawing of wire and tubing; ironing; necking; nosing; and upsetting.

ADVANTAGES OF PHOSPHATE COATING WITH "GRANODRAW" PRIOR TO COLD FORMING STEEL

The following are among the advantages indicated for phosphate coating with "Granodraw" prior to cold forming steel:

Drawing of wire, bars, tubing, etc. — Improved lubrication; improved surface; less scratching; reduced pull; greater percent reduction per pass; reduced die wear; longer die life; lower die maintenance and cost; reduction in corrosion.

Drawing of stampings, shells, shell cases, etc. — Improved lubrication; reduced breakage; reduction in scrap; deeper draws; less scratching; elimination of some annealing; less wear on dies.

Cold Extrusion — Improved lubrication; increased strength of parts; improved surface; reduction in load on press; greater dimensional accuracy; more uniform wall thickness; longer extrusions; elimination of some annealing; less corrosion.

CHEMICALS ACP PROCESSES

WRITE FOR FURTHER INFORMATION ON "GRANODRAW" AND ON YOUR OWN METAL PROTECTION PROBLEMS.

CHEMICALS ACP PROCESSES

tute, Pittsburgh, Pa. This fellowship will be sustained at the Institute by a grant from the Sarah Mellon Scaife Foundation of Pittsburgh, and its projects will be organized and supervised by Dr. Dickson Reck, advisory fellow. Dr. Reck will work in cooperation with research specialists of the Institute and with national authorities and societies.

IRON ORE IS MINED BENEATH OCEAN FLOOR

▲ Iron ore is mined beneath the sea more than two miles from shore near Bell Island, Newfoundland, according to American Iron and Steel Institute. A system of belt conveyors is being installed to help bring the ore from beneath Conception Bay to the surface on the island. The system will be able to lift 1,000 tons of ore an hour from a depth of 1,730 ft. According to a published report, this Wabana Mine is expected to supply 2,800,000 tons of ore in 1952.

The first iron ore was shipped from an outcropping of a deposit on Bell Island in 1895. When the deposit on shore was exhausted, it was found that the ore extended under Conception Bay. The miners began the present system of driving slanting shafts from the shore under the water. They remove some of the ore and leave some in the form of pillars to support the load of overburden and seawater. Shafts are driven at three different levels.

SHENANGO REPLACES FIRE RAZED FACILITY

▲ A new pattern shop and locker room building to replace a firerazed facility of the Shenango-Penn Mold Co. at Neville Island, Pa., has been completed by Rust Engineering Co.

The new structure will house the pattern shop for the company's foundry, and a shower and locker room to accommodate 200 men. Last year a fire totally destroyed these facilities.

ALLOY PLANT OPENED NEAR CAMBRIDGE, OHIO

▲ Vanadium Corp. of America has begun the production of alloys at a new modern plant at a 120-acre site

How to shackle this steel production thief

EXCESSIVE down-time in open hearth steel furnaces—a costly thief of steel production—can be shackled by Permanente 165 *periclase* ramming mix.

Patented Permanente 165 bonds itself to *full depth* by means of crystal-bridging. A ceramic bond begins forming at temperatures as low as 1500°F. Thus a deeper bond is obtained at normal burn-in temperatures—with no formation of fluids.

Permanente 165 *retains higher refractoriness* during long campaigns. Accurately-sized, preshrunk sea water magnesia periclase grains insure *high density*.

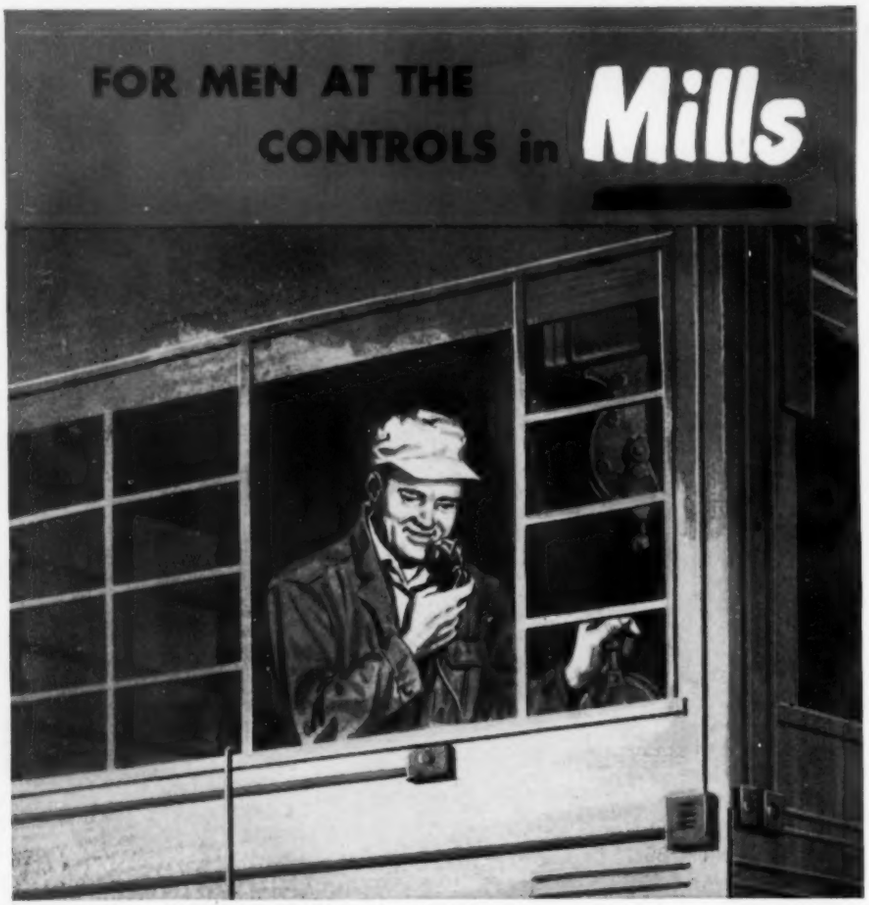
As a result, Permanente 165 gives you a dense, highly refractory bottom of high hot load strength that minimizes breakthroughs. And down-time for repairs between heats is cut to a minimum. This means increased production time, increased tonnage per year.

YOUR Kaiser refractory engineer will give prompt attention to your refractory problem—will offer, where desired, research, design and installation service to give you maximum production most economically. Write for descriptive literature on Permanente 165 and on the companion ramming mix, Permanente 84. Principal sales offices: *Chemical Division*, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California. First National Tower, Akron 8, Ohio.

Kaiser Chemicals

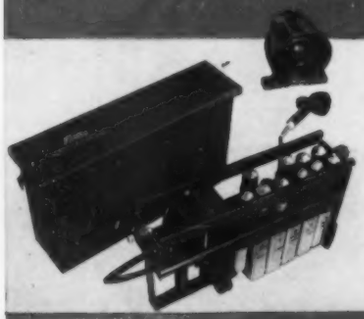
Pioneers in Modern Basic Refractories

Basic Refractory Brick and Ramming Materials • Dolomite • Magnesia • Magnesite • Alumina • Periclase



Femco

TROLLEYPHONES
GET THINGS DONE



Wherever there are power rails or power lines, installations of Femco Trolleyphones can speed production, cut costs, promote safety and improve work conditions.

In better team work alone, Femco Trolleyphones pay for themselves. Consider—As many moving or stationary stations as are needed all brought in continuous contact with dispatchers and each other!

THE FEMCO TROLLEYPHONE IS ONE OF THE SIMPLEST, MOST USEFUL COMMUNICATION SYSTEMS EVER DEVISED.

Demonstrations Arranged at No Charge
Write for Femco Bulletin No. 25

NEW PLUG-IN MODEL
2550 Series

Years ahead in engineering and design! All parts plug in like tubes! Takes 30 seconds to replace spare parts! Cuts down time!

Let a Femco ENGINEER PROVIDE "YOUR VOICE OF ACTION"

FARMERS ENGINEERING & MANUFACTURING COMPANY
549 Brushton Ave., Pittsburgh 21, Pennsylvania

near Cambridge, Ohio. The new properties are situated about 100 miles from the company's new $8,000,000 alloy-producing plant at Graham, W. Va.

In addition to a three-section mill building containing electric arc furnaces for producing alloys, the Ohio plant contains general offices, a research laboratory and a pilot plant for the development and testing of new products. The plant, which is served by the Pennsylvania Railroad Co., is centrally located with respect to its raw material supply and to major markets for its finished products.

Vanadium Corp.'s aluminum alloy-producing division will be moved to a new plant late in August from the leased Chester, Pa. plant which has been returned to the United States Government and is being reactivated by the Air Corps. Initial operations in Cambridge will consist of the melting of secondary aluminum and the manufacture of aluminum alloys.

The production of ferro vanadium, grainal alloys, low carbon ferro titanium and other alloys is scheduled to begin at the new Cambridge plant in the spring of 1953. Since most of the current output of the aluminum division is employed by the company in its manufacture of vanadium alloys, concentration of these two operations in a single plant should yield important economies.

SAUGUS REPLICA IS NOW OPERATING

▲ As sluice gates opened, a stream of water plunged over a giant waterwheel at Saugus, Mass., recently, in a dramatic demonstration of the use of power by colonial New Englanders, who built at Saugus the first successful ironworks in America, in 1644.

The wheel, 17 ft in diameter, turned on a sturdy oaken shaft, to the cheers of 300 members of the first Ironworks Association, holding their annual meeting at the ironworks site. It is a replica of the original 14-hp waterwheel which drove a bellows for the Saugus blast furnace.

Furnace, wheel and bellows have been completely restored in their original locations by the Association, which also will reconstruct forges, "fineries" and a slitting mill. Dedication of the restored ironworks is

Customers TELL US about

NATIONAL
TRADE-MARK

Standardized Brushes!

STANDARDIZATION of industrial motor brushes means different things to different people. But no matter how they define it, National Carbon's pioneer brush-standardization program is making their jobs *easier*, helping them do *better* work, *saving* their company *time* and *money*.

PRODUCT—"Practically every machine and part in this plant is *standardized*," said one Chief Electrician. "Why not brushes, too? The quality of our own products is constantly being improved through standards procedure." **HE'S RIGHT!** Brushes are no exception to the rule that volume production of *standard* items results in greater uniformity, closer control of materials and processes.

PRICE AND DELIVERY—"Standardization?" said this Purchasing Agent. "If that's what's behind your FLAT PRICE deal, I'm for it! I don't have to worry about quantity discounts and your on-the-button deliveries take a real headache out of inventory!"

HE'S RIGHT, TOO! Standardized brushes are mass-produced *for* stock . . . shipped *from* stock at the same low, FLAT price for 100 or 100,000 brushes!

PACKAGE—"You wouldn't believe how many different ways brushes are packed," one Stores Keeper told us. "Bags, barrels, boxes of every size and shape. But National Carbon's *standardized* cartons are tops. They pack neat, stack straight, are clearly marked and keep their shape."

RIGHT AGAIN! Mass production enables us to deliver a better package in a minimum number of carton sizes.

LOW LIGHT BILLS . . . mark phenomenal acceptance of "EVEREADY" No. 1050 Industrial Flashlight Batteries by a broad cross-section of industry. Delivering *twice the usable light* of any battery we've ever made before, it will not swell, stick or jam in the flashlight . . . has no metal can to leak or corrode.

Write for Bulletin CP-2426
"NATIONAL" STANDARDIZED BRUSHES

The terms "National", "Eveready" and the Three Pyramids device are registered trade-marks of Union Carbide and Carbon Corporation

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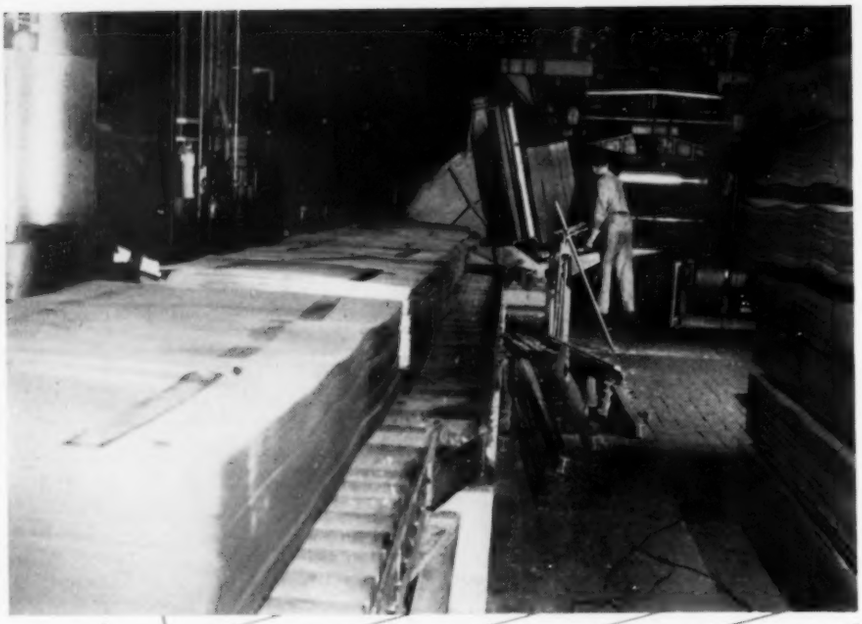
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N.Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada:
NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg



for the best solution to that handling problem . . .

● When faced with material handling problems —whether they involve conveying coils or sheet packs—keep in mind the service of Mathews Engineers which is readily available to you—Engineers who can help you to get the right answers to these problems without confusion or delay. You will find that it pays to depend on such experienced sources of supply, for behind your Mathews representative is a large engineering staff, a highly skilled production force, modern plants and a background of nearly 50 years of service to the metal-working industries. So, when handling problems turn up, give them to Mathews Engineers. You'll be glad you did.

MATHEWS CONVEYERS

GENERAL OFFICES . . . . . *Mathews Conveyer Company*
ELLWOOD CITY, PENNSYLVANIA

PACIFIC COAST DIVISION . . *Mathews Conveyer Company West Coast*
SAN CARLOS, CALIFORNIA

CANADIAN DIVISION . . . . . *Mathews Conveyer Company, Ltd.*
PORT HOPE, ONTARIO

scheduled for 1953. Built as a shrine to industrial pioneers, it will not be used to make iron.

"Saugus was the first successful blast furnace and iron producer operated in colonial America," Dr. Rufus E. Zimmerman, of United States Steel, told the annual meeting. "It was an American 'first,' capable of producing 465 net tons of iron a year. From its brave and troubled beginning there has issued a steel industry with facilities for producing annually 110 million net tons of ingots. The capacity of Saugus has been multiplied, during 300-odd years, by more than 236,500. A modern blast furnace consumes enough material every twenty-four hours to have run the Saugus furnace three years."

"Good products issued from the Saugus operations," Dr. Zimmerman continued, "good both chemically and physically. The iron ore carried barely 38 per cent iron, in comparison with our usually more than 50 per cent. Refractories were sandstone, compounded by Mother Nature, not the well-developed formulas of the enlightened ceramic engineer. Air for the blast was not preheated. Bellows were in vogue, but there was no turbo-blower. Charcoal, the forerunner of coke, had to be prepared by felling acres of trees which were then laboriously and crudely processed to furnish metallurgical reagent and fuel. The steam engine was more than a century distant and no one had even dreamed of industrial electric power.

"Accurate and comprehensive data are not available as to the normal length of the working day, hourly rates, shift differentials, paid vacations and holidays, premium compensation for overtime, pensions, insurance, hospital benefits and other working conditions. We do not even know that the men of Saugus, with their busy days, devoted much time to these subjects.

"Founders of the Saugus ironworks were not following an American tradition, they were creating one. Their spirit of venture and independence, unafraid of difficulties, willing to work to win, has been coursing through the channels of the iron and steel industries through the intervening three centuries, and will continue to work wonders as long as it remains unimpaired by stultifying factors impressed from without."

President J. Sangar Attwill report-

Easier to Maintain!

EVERY PART REMOVABLE FROM FRONT *in* NEW CLARK *type* "CY" AC STARTERS

Besides featuring an entirely new principle of arc interruption which substantially lengthens contact life, CLARK Type "CY" AC MOTOR STARTERS provide faster and easier inspection and maintenance by a new design which permits removal of every part from the *front*. No special tools are required.

Figure 1 shows the clean-cut open construction with easy access to wiring terminals and all components.

1. To inspect movable contacts, simply push down contact bars to depress springs "I".
2. To inspect stationary contacts, open snap-action cover clips "B" releasing lower arc shield "C" (Figure 2).
3. To replace movable contacts, loosen captive screws "D" and remove contact arm. Contacts are now quickly removed by twisting in either direction. (Figure 3).
4. With contact arm removed, stationary contacts can be replaced by dropping lower arc shield and turning contacts with wrench.
5. Magnet coil is easily changed by removing coil connections and loosening captive screws in coil clamps "G". Now remove armature "F" by pushing snap-in pin "E" in direction of knurled head. (Figure 4).
6. Stationary Magnet Frame "H" can now be removed by taking out four screws holding it to base plate.
7. To insert or replace an overload heater coil, remove one screw "J" and lift off cover plate.
8. An entire overload relay assembly can be removed by disconnecting wiring and taking out two screws holding it to the base plate.
9. Control circuit relay block can easily be removed from the front by taking out one screw, after moving contact arm has been removed as in Figure 3.
10. Entire control unit—on base plate—can be lifted from cabinet by loosening three screws "A".

Could anything be simpler?

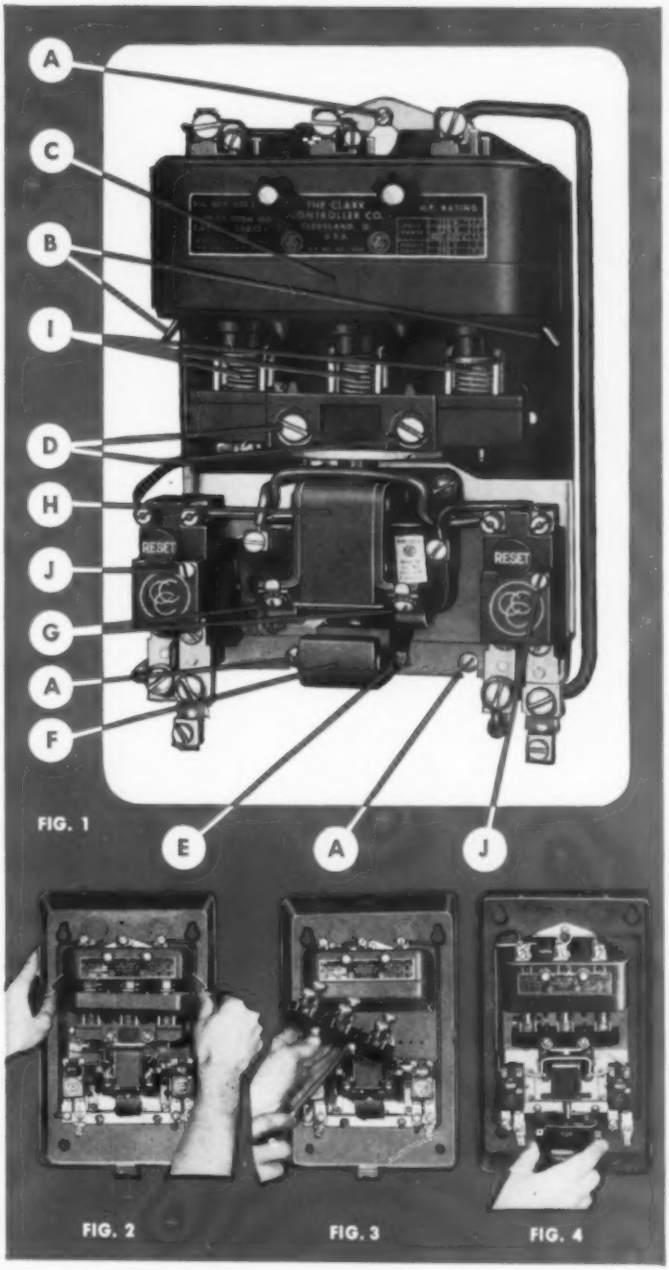


FIG. 1

FIG. 2 FIG. 3 FIG. 4

PLEASE VISIT OUR BOOTHS 68-69-70-71—IRON & STEEL EXPOSITION, SEPTEMBER 30, OCTOBER 1-2-3

Complete accessibility from the front on CLARK Type "CY" AC Motor Starters makes a big hit with production and maintenance men. Available in sizes 0, 1, 2 and 3. Write for details.

THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1146 EAST 152ND STREET, CLEVELAND 10, OHIO

Maybe your business isn't LUMBER...

...or PINEAPPLES

BUT... just imagine the savings you could make, the problems you could solve by handling your materials with ROSS Straddle Carriers, the most flexible and most adaptable mass material handling method known!

ROSS engineers will be glad to work with your materials handling men in exploring the possibilities of ROSS Straddle Carriers for your operations . . . there's no obligation.

Send for details on ROSS Straddle Carriers . . . 10,000 lb., 20,000 lb., 35,000 and 45,000 lb. capacities.

Rely On ROSS

THE ROSS CARRIER COMPANY

Direct Factory Branches and Distributors throughout the world.

400 Miller St., Benton Harbor, Michigan, USA

ed that membership in the Association now exceeds 500.

REFRACTORIES PLANT COMPLETED IN WEST

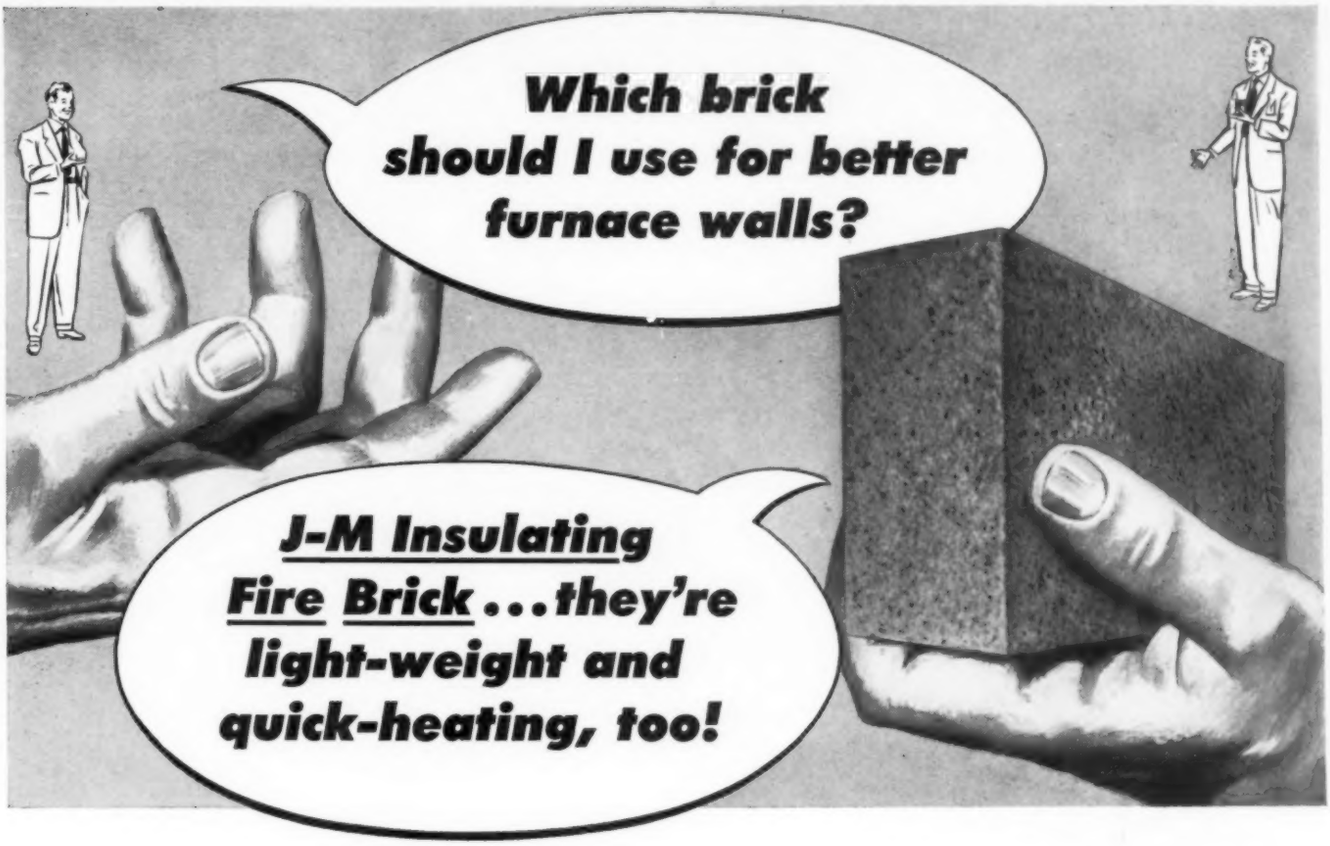
▲ Construction of General Refractories Co.'s new $1,000,000 plant in Los Angeles, Calif., for the manufacture of unburned basic brick is now completed and in full operation. The Maywood plant, named for the section of Los Angeles in which it is situated, is General Refractories' second production facility in that city and will account for all of the company's unburned basic refractory brick produced west of the Rocky Mountains, increasing its West Coast manufacturing capacity by 100 per cent. The older Vernon plant, acquired by purchase in 1943, is now devoted exclusively to the manufacture of silica brick.

Situated on a 16 acre plot, the new Maywood plant has 28,000 sq ft of manufacturing and storage space. Of modern design, the structure is basically steel, concrete and asbestos siding. A translucent plastic material stripped around the building permits entry of 60 per cent of outdoor light. The latest manufacturing techniques have been incorporated in the new plant's operational procedures which permits production to flow in a straight line from raw materials to finished product.

The Maywood plant is the first new manufacturing unit to be completed under General Refractories current $12,000,000 expansion and improvement program.

OUT in the FIRST ROUND

In every election fight, the first round is Registration. You'll be OUT then, with no chance to vote, unless you register. Find out WHEN, WHERE and HOW by phoning the office in charge of elections, or your City Hall or County Court House. And remind your friends so you'll all be in on that exciting final round.



6 types . . . for savings in services up to 3000F

Because of their quick-heating and low-heat transfer characteristics, Johns-Manville Insulating Fire Brick are efficient fuel-savers for use at operating temperatures up to a full 3000F on the insulation.

Each type of J-M Insulating Fire Brick has the correct balance of thermal and physical properties that assures maximum economies within a specific temperature range. All types are *quick-heating* . . . operating temperatures are reached in a short time, thereby saving fuel.

Identical materials can also be obtained in large size units known as Johns-Manville Insulating Fireblok. Fireblok have the same properties as the brick, but are made in extra large sizes for added construction economies. The large units can be installed faster . . . require fewer joints and less bonding mortar. During rebuilding or repair, furnace down-time is appreciably shortened with Fireblok construction.

A Johns-Manville insulation expert will gladly explain the advantages and economies of using J-M Insulating Fire Brick and Fireblok for refractory linings or as back-up insulation behind other refractory protection. Write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay St., Toronto 1, Ontario.

Properties	Types of Insulating Fire Brick and Fireblok					
	JM-3000	JM-28	JM-26	JM-23	JM-20	JM-1620
Temperature limit	†3000F	†2800F	†2600F	†2300F	†2000F	‡2000F †1600F
Density, lb per cu ft	63—67	58	48	42	35	29
Transverse strength, psi	120	120	125	120	80	60
Cold crushing strength, psi	300	150	190	170	115	70
Linear shrinkage, percent	*0.8 at 3000F	4.0 at 2800F	1.0 at 2600F	0.3 at 2300F	0.0 at 2000F	0.0 at 2000F
Reversible thermal expansion, percent	0.5—0.6 at 2000F	0.5—0.6 at 2000F	0.5—0.6 at 2000F	0.5—0.6 at 2000F	0.5—0.6 at 2000F	0.5—0.6 at 2000F
Conductivity (Btu in. per sq ft per F per hr at following mean temperatures)						
500F	3.10	2.00	1.92	1.51	0.97	0.77
1000F	3.20	2.50	2.22	1.91	1.22	1.02
1500F	3.35	3.00	2.52	2.31	1.47	1.27
2000F	3.60	3.50	2.82	2.70	....	....

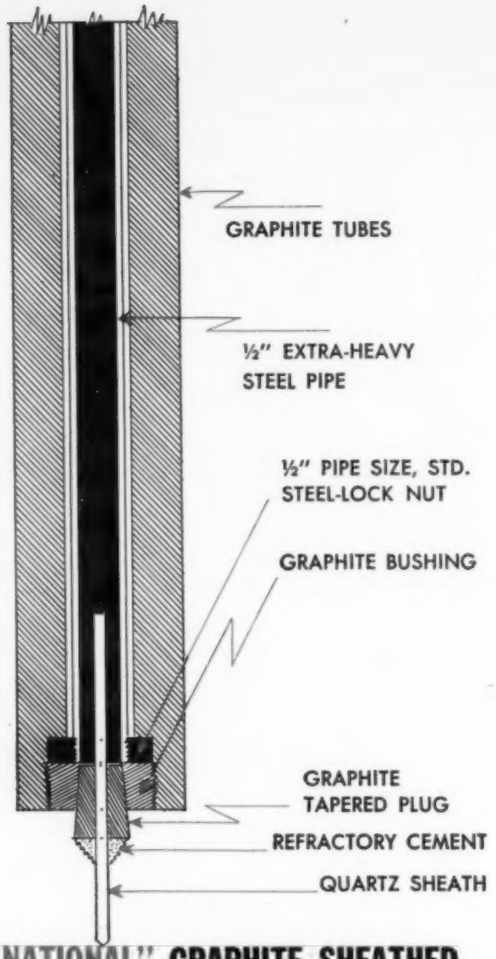
*24-hr Simulative Service Panel Test; all others 24-hr soaking period. †Back-up or exposed. ‡Back-up only.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** *first in* **INSULATIONS**

In Furnace and Foundry...

These SMALL PARTS do a BIG JOB

● High temperature applications of "National" Carbon and Graphite are not limited to big-tonnage items. A part of National Carbon's service is to develop *any* application, however small, where the unique properties of carbon and graphite assure a convenience and economy to the user. In the following two instances, a few *pounds* of graphite serve literally *tons* of metal . . . efficiently and at a saving.



"NATIONAL" GRAPHITE FLUXING TUBES

Can't be equalled by any other material for the introduction of purifying gases into molten metal. Graphite can't melt in the bath, can't contaminate the metal. Its low coefficient of expansion prevents cracking and spalling. Metal and dross do not adhere tightly to it. And whatever gases are used, graphite will not corrode.

"NATIONAL" GRAPHITE-SHEATHED THERMOCOUPLE ASSEMBLY (Typical)

Only graphite could provide the degree of low-cost, trouble-free protection required by thermocouple assemblies of this type for the immersion method of measuring open hearth and electric furnace bath temperatures. Reclamation and maintenance for re-use are simple, quick, and economical. Molten metal won't stick to the graphite parts and they're immune to thermal shock.

HERE'S HOW TO LICK HY HEET

National Carbon Company
30 E. 42nd Street
New York, N. Y.

PLEASE SEND INFORMATION ON:

☐ Thermocouple Sheath Parts ☐ Fluxing Tubes

NAME_____

COMPANY_____

ADDRESS_____

The terms "National" and "Eveready" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, New York
District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco
IN CANADA: National Carbon Limited
Montreal, Toronto, Winnipeg

LOW LIGHT BILLS . . .

. . . mark phenomenal acceptance of "EVEREADY" No. 1050 Industrial Flashlight Batteries by a broad cross-section of industry. Delivering twice the usable light of any battery we've ever made before, it will not swell, stick or jam in the flashlight . . . has no metal can to leak or corrode.

BLAST FURNACE LININGS • BRICK • CINDER NOTCH LINERS • CINDER NOTCH PLUGS • SKIMMER BLOCKS • SPLASH PLATES • RUNOUT TROUGH LINERS • MOLD PLUGS • TANK HEATERS

Personnel News...

Louis Moses has been appointed mill engineer for the Bethlehem Steel Co. and will be located at Bethlehem, Pa. Mr. Moses was previously superintendent rail mill and roll department at the Sparrows Point, Md., plant. He has been very active in AISE affairs and is the author of numerous articles on various phases of rolling. Mr. Moses started his steel mill career at Johnstown, Pa. with the Cambria Steel Co. as office boy, and successively progressed as apprentice, machinist and mechanical draftsman on mill and machinery construction, maintenance, etc. He then entered the field of roll designing, where his experience embraced large and small rolling mills, extending later to the development of the varied rolling and manufacturing facilities of the expanding Sparrows Point plant of Bethlehem Steel Co., and to the supervision of operations of the rail mill at that plant.

William M. Frame was named executive assistant, operating department for United States Steel's National Tube Division, Pittsburgh, Pa. Mr. Frame has been with the former Central Alloy Steel Co., Massillon, Ohio, the former Otis Steel Co., Cleveland, Ohio, and Spang-Chalfant Co., Ambridge, Pa. Mr. Frame has recently been vice president and works manager, Kerotest Manufacturing Co., Pittsburgh, Pa.

K. C. Gardner, Sr. was elected chairman and chief executive officer of United Engineering and Foundry Co., to fill the vacancy created by the recent death of **F. C. Biggert, Jr.** Mr. Gardner has been active in the affairs of the company since 1899. **Geoffrey G. Beard,** formerly in the position of executive vice president, was elected president and general manager. **K. C. Gardner, Jr.** becomes executive vice president, and will continue in direct charge of plant operations along with the general executive duties of his new office. **Maurice P. Sieger** becomes vice president and senior engineer of the company, and has been delegated all of the engineering and research activities which the late Mr. Biggert so ably performed prior to his death on February 10.

J. O. Tompkins has been appointed assistant chief metallurgist for Keystone Steel and Wire Co., Peoria, Ill. Mr. Tompkins will be responsible for the maintenance and improvement of quality of the steel and wire products in the steel plant and wire mill. **Harold Fales** has been named wire mill metallurgist for Keystone. Mr. Fales will be in charge of quality control of wire and wire products.

Robert S. Gruver has been elected vice president in charge of planning of Armco Steel Corp., Middletown, Ohio. This is a newly created office in Armco's top executive structure. Since 1949, Mr. Gruver has been serving as vice president in charge of operations.

Walker Anderson, 59, secretary and vice president in charge of sales and engineering for Patterson-Emerson-Comstock, Inc., engineers and constructors, Pittsburgh, Pa., died July 22. Mr. Anderson started with General Electric Co. in test at Schenectady, N. Y., in September, 1913. His service with General Electric was then interrupted for a time for military service. In June of 1919 he returned to General Electric and became a sales engineer in their Pittsburgh office, retaining this position until April, 1946 when he resigned to join Patterson-Emerson-Comstock, Inc. as assistant secretary and manager of sales and engineering. In May, 1950 he was made secretary of the firm, and in February, 1951 was appointed vice president in charge of sales and engineering.

J. E. Mullen was named Ohio and Pennsylvania sales representative of Brad Foote Gear Works, Inc., Chicago, Ill. Mr. Mullen, whose headquarters are in the G. Daniel Baldwin Building, Erie, Pa., has long been prominent and widely known in industry and association activities. From 1911 to 1929 he was associated

LOUIS MOSES

WM. M. FRAME

GEOFFREY G. BEARD

K. C. GARDNER, JR.

with the A. D. Nuttal Co., Pittsburgh, where he became assistant to the vice president. In 1929 he joined the National Erie Corp., Erie, Pa., as manager of the Pittsburgh office. Promoted to sales manager in 1931, he was elected vice president in charge of sales in 1936. He remained with the company until it was sold in October, 1951, to the Bucyrus-Erie Corp., Milwaukee, Wisc.

D. F. Bradley was named manager of the Detroit, Mich., district sales office of Shell Chemical Corp. Mr. Bradley succeeds **W. E. Keegan** who has been appointed to the position of assistant to the vice president, marketing. Mr. Bradley had been serving as manager of the solvents department of Shell Chemical's eastern division, in New York, N. Y.

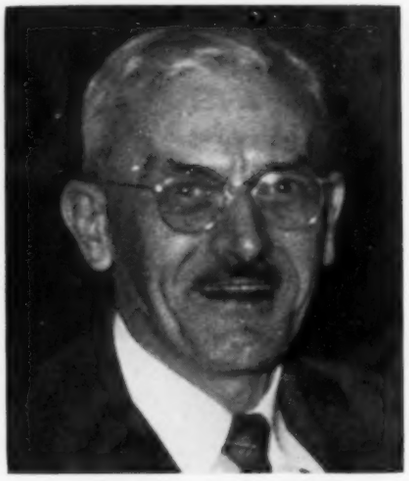
Gerald J. Weckmueller, assistant superintendent of blast furnaces, Inland Steel Co., Indiana Harbor, Ind., died recently.

Adam Lilly, superintendent of the mason department, Inland Steel Co., Indiana Harbor, Ind., died recently.

William F. Waina has been named manager of the newly formed aeronautical and special products division of Hagan Corp., Pittsburgh, Pa. Mr. Waina has been a member of the Hagan sales staff since 1940.

Charles G. Sims was named division manager, small motor switch sales, which will include aircraft switches, circuit breakers and contactors, for Cutler-Hammer, Inc., Milwaukee, Wisc.

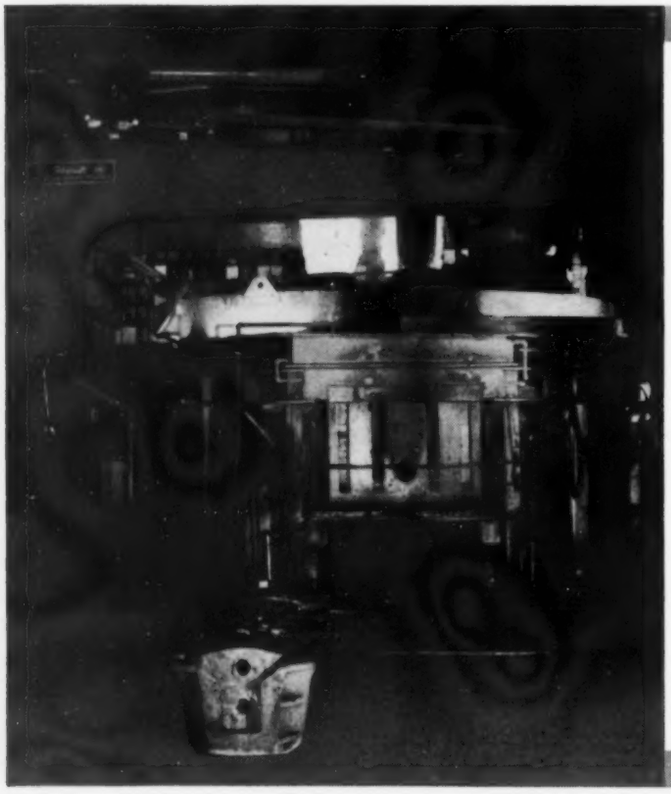
George H. Acker has been elected executive vice president of Cleveland Worm & Gear Co., Cleveland,



GEORGE H. ACKER

Ohio, as well as its subsidiary, Farval Corp. Mr. Acker joined the firm in 1923 as chief engineer. In 1942, he was appointed vice president in charge of engineering and continued in that capacity until this latest promotion.

Horace Douglass Moulton, now vice president-opera-



Heroult

ELECTRIC MELTING FURNACE

. . . as ever, the dependable furnace for the production of high-grade stainless, alloy and rimming steels.

Removable roof of new design now available for the larger furnaces.

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UNITED STATES STEEL COMPANY

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AMERICAN BRIDGE

USS

UNITED STATES STEEL

STOP RUST! with RUST-OLEUM

Every *rustable* metal surface needs **RUST-OLEUM**—the *exclusive* formula *proved* in all types of industry, at sea, above and below ground for over 25 years! Goes on easily by brush, dip or spray . . . dries to a *firm, elastic, decorative* finish that resists salt air, rain, snow, heat, fumes, smoke, etc. **RUST-OLEUM** may be applied *directly over surfaces already rusted without removing all the rust!* Simply scrape and wire-brush to remove rust scale and loose particles. Sandblasting and other costly preparations are not usually required. So easy to use that one man often does the work of two! Specify **RUST-OLEUM** to your contractor, architect or maintenance department. Prompt delivery from Industrial Distributor stocks in principal cities.

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RUST-OLEUM BEAUTIFIES AS IT PROTECTS — AVAILABLE IN ALL COLORS, ALUMINUM AND WHITE

FREE SURVEY: Place your rust problems in the hands of a **RUST-OLEUM** specialist. He will conduct a survey, including *applications, specific tests,* and *recommendations. No cost or obligation.* See Sweets for catalog and nearest **RUST-OLEUM** distributor, or write for literature on your company letterhead.

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- ☐ Complete Literature.
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tions of U. S. Steel Products Division of United States Steel Co., Pittsburgh, Pa., has been appointed assistant vice president-raw materials, United States Steel Co.

FRANCIS H. WICKLINE

Francis H. Wickline has been appointed electrical engineer for the National Tube Division of United States Steel Co., Pittsburgh, Pa. Mr. Wickline has been employed in the construction engineering department at the Lorain, Ohio, plant of National Tube since 1946.

George McCuskey has joined Youngstown Sheet and Tube Co., Youngstown, Ohio, as assistant to the president. His duties will be devoted primarily to financial phases of the industry.

J. P. Moore has been appointed district manager of the Cleveland sales office of Electric Controller and Mfg. Co., Cleveland, Ohio. Mr. Moore started with

J. P. MOORE

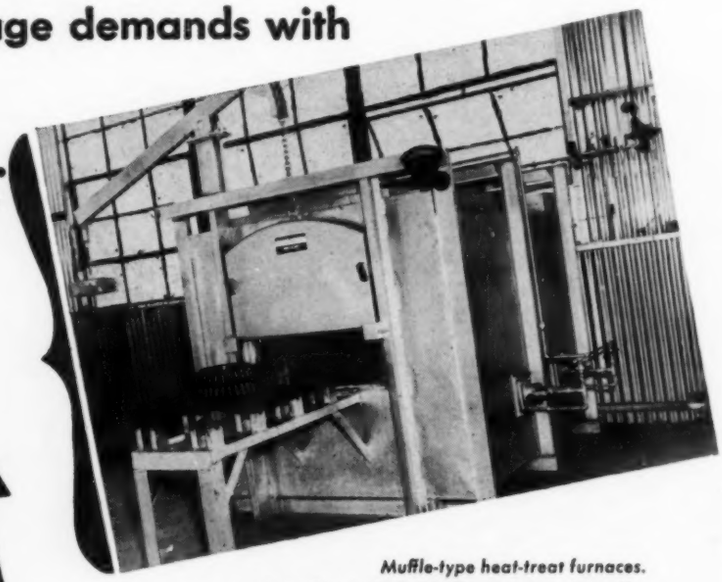
EC&M in 1923, and has been in the Cleveland sales office since then.

Hugh C. Seeley was appointed to the position of sales-service supervisor for Baker-Raulang Co., Cleveland, Ohio. **Walter E. Schoch** was named service department manager. Both Mr. Seeley and Mr. Schoch are veteran Baker employees. Mr. Seeley joined the company in 1904, when it was producing Baker electric passenger cars. Mr. Schoch has been with Baker since 1919.

Meet today's increased tonnage demands with

Custom Engineered

FURNACES by Grant Watson



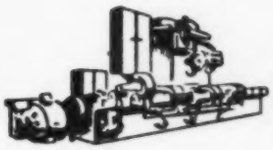
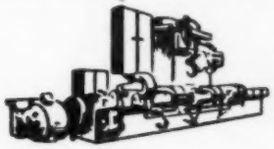
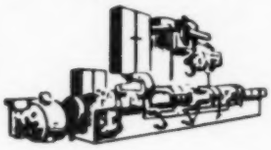
Muffle-type heat-treat furnaces. One of many individually engineered installations designed, built and installed complete by Grant Watson.

Designers of individually engineered heating and heat treating furnaces, both gas and oil fired, for reheating slabs, billets, rods, bars and blooms; forging; soaking pits; annealing and normalizing; stress relief; and other industrial heating applications.

Grant Watson "Custom Engineered" furnaces deliver maximum heating efficiency, uniform product quality, positive temperature control plus the versatility and flexibility that pays off in increased tonnage and economical operation. Regular COST-FREE SERVICE after installation reduces maintenance costs, assures trouble-free performance day-in and day-out.

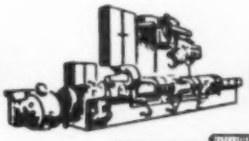
Write, wire or call for instant service on custom engineered furnaces to meet your requirements and specifications

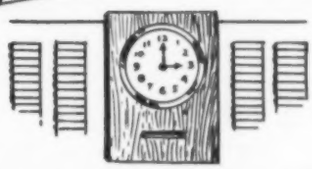
GRANT WATSON CONSTRUCTION COMPANY • 1398 So. Santa Fe Drive, Denver, Colorado

GUIDE PRODUCTION  GUARD COSTS  WITH ENLARGED BATTERIES OF BONNOT  BILLETEERS . . .

Those who *guide production* and *guard costs* in the basc processing of quality steels are building up their batteries of Bonnot Billeteers. In fact, because of rugged reliability established over years and years of service, many big companies that already are "multiple users" are further expanding Billeteer facilities.

With labor costs irresistibly climbing in your billet-cleaning, as in other phases of production, there is strongly-increased incentive for the kind of smooth, profit-making mechanization that flows from the wider use of the Bonnot Billeteer.

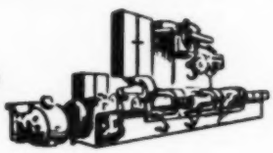
TIME IS MONEY **ANY BILLETEERS**  **INSTALLED**



— SINGLE OR MULTIPLE — WILL CUT TIME

CUT COSTS **CUT LOSSES** **CUT MANPOWER**

TURNOVER PROBLEMS. WHY NOT VIGOROUSLY INVESTIGATE THE MERITS OF EARLY ACTION

TOWARD BETTER BILLET-CLEANING THROUGH BONNOT BILLETEERING? 

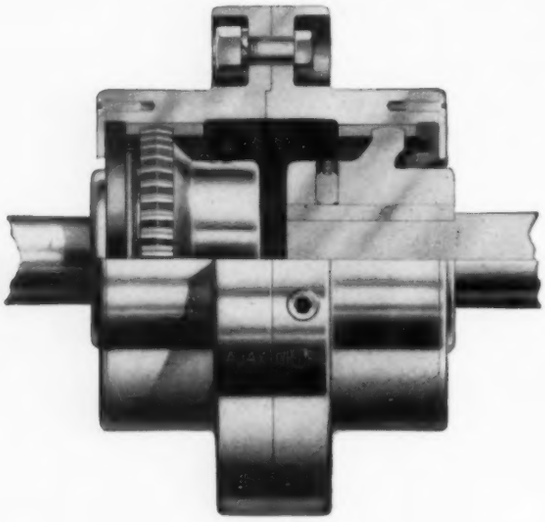
Engineered For Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO

Also Manufacturers of — SAWING • PULVERIZING AND MIXING EQUIPMENT • BILLET INSPECTION TABLES
CRUSHING • DUST PUG MILLS • SINTER PLANT PUG MILLS

AJAX DIHEDRAL

New Coupling
STEEL MEN
Have Waited For



▶ Ability of Ajax Dihedral Couplings to handle extreme misalignment is the talk of hard-boiled steel men everywhere.

Exclusive Dihedral tooth shape provides for misalignment up to 4 degrees as stock off-the-shelf couplings. 6, 8, 10 and 12 degree teeth cut to order.

Save costly hours of setup, change-over and maintenance time. Line up motors in minutes not hours.

Write for facts on this radically new and exclusive coupling.

AJAX FLEXIBLE
COUPLING CO. INC.
WESTFIELD, NEW YORK

Ernest E. Kugel was appointed director of sales in charge of rolling mills of Hydropress, Inc., New York, N. Y.

ERNEST E. KUGEL

Robert G. Evans, one of the original founders of the Clipper Manufacturing Co., has announced the formation of a new company to distribute masonry and concrete sawing equipment. Headquarters for the Robert G. Evans Co. will be at 6315 Brookside Plaza, Kansas City, Mo.

William L. Denniston has recently joined the sales staff of the Berry Division, Oliver Iron and Steel Corp., Pittsburgh, Pa., as a sales engineer. Mr. Denniston was formerly connected with the engineering staff of the John Deere Harvester Works at East Moline, Ill.

Arthur C. Bryan has been appointed vice president in charge of sales for National Carbon Co., a division of Union Carbide and Carbon Corp., New York, N. Y. Mr. Bryan has been with National Carbon in various sales activities since 1935. He started with the company

ARTHUR C. BRYAN

as an industrial salesman in the Chicago office and five years later was appointed a district manager in the New York office. From that position he moved to Cleveland, Ohio, as assistant manager of the carbon sales division there. Later, he held the post of division manager of the Kansas City sales office. After that, Mr. Bryan went back to New York where he was appointed

the BEST electrical connectors that money can buy

No question about it . . . JOY plugs and receptacles are heavy industry's outstanding electrical connector values! Molded as one-piece Neoprene units, they can't crack or smash out of shape when dropped and won't become mushy when smeared with grease or oil. When engaged, contacts on JOY connectors are protectively housed in resilient Neoprene. Cork-like action of the famous JOY water-seal prevents metallic dust from accumulating around contacts, eliminating the danger of high resistant shorts . . . *always a possibility with metal encased attachable type connectors.* Write for information on the complete line today. Let us show you how JOY plugs and receptacles can reduce your maintenance and replacement costs. Full details including literature available without obligation. Ask for them, now!

Serving Today on:

- ★ *Coiling Motors*
- ★ *Conveyors*
- ★ *Electro-Magnets*
- ★ *Man Coolers*
- ★ *Motor Controls*
- ★ *Power Leads*
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- ★ *Sand Slingers*
- ★ *Shears and Benders*
- ★ *Transfer Cars*
- ★ *Welding Leads*

Consult a Joy Engineer

. . MORE THAN 100 YEARS OF ENGINEERING LEADERSHIP

M. E. 452.2

JOY MANUFACTURING COMPANY

HENRY W. OLIVER BUILDING, PITTSBURGH 22, PENNSYLVANIA

IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LTD., GALT, ONTARIO

Filling your complete needs for Steel Mill Space Conditioning—

1 CRANE CAB CONDITIONERS

• The condenser is located at any convenient place on crane, and evaporator (cooling coil) is placed in cab. The two units are connected with refrigerant lines properly secured and protected against breakage. Condensers are air-cooled, assuring trouble-free service with but little maintenance.

2 VENTILATING HEATER FOR GENERAL PURPOSE CRANES

Available with filter unit for crane cabs and isolated spaces, this 49-VHG cab unit serves the year around, furnishing ventilation and air movement throughout the cab. Compact, efficient, inexpensive.

3 PULPITS OPERATING STANDS and CONTROL ROOMS

The line of Aire-Rectifiers is complete for all types of mill pulpits — for those of the most modern design to existing pulpits where costs must be kept down. Many are interchangeable with crane cab Aire-Rectifiers, thereby keeping service parts stocks at a minimum.

THE LINTERN CORPORATION

P. O. BOX 428 • PAINESVILLE, OHIO

assistant general sales manager for the company, and in 1949 was promoted to general sales manager.

Robert C. Carruthers was appointed assistant sales manager, welding products, of American Manganese Steel Division, American Brake Shoe Co., at Chicago Heights, Ill. Mr. Carruthers started with American Brake Shoe in 1950 as metallurgical assistant, and was sales development engineer with American Manganese Steel Division prior to his appointment as assistant sales manager.

E. W. (Ned) Taylor, Jr., was appointed as West coast representative for S. G. Taylor Chain Co. Offices will be maintained in the Los Angeles, Calif. area.

E. G. Weston, 62, special liaison engineer for the Wheeling Steel Co. works at Steubenville, Ohio, died June 29.

Kenneth R. Dodge has recently joined the Cleveland, Ohio, office of Okonite Co. as a sales engineer handling wire and cable sales to industrial plants and utilities in northern Ohio.

LIONEL Y. GREENE

Lionel Y. Greene was elected president of the General Refractories Co., Philadelphia, Pa. **Floyd L. Greene,** who has been president of the corporation since 1937, was elected to the post of chairman of the board, and will remain the senior executive officer of the company and its subsidiaries. Mr. Lionel Greene, who has been with General Refractories since 1923, has been vice president of the company since 1936. In 1948 he was made executive vice president.

Seven regional industrial sales managers have been named by Minneapolis-Honeywell Regulator Co. Those appointed and the regions in which each will have charge are: **Jack E. MacConville,** the southeast with headquarters in Atlanta, Ga.; **Alfred J. McCullough,** the central region with headquarters in Cleveland, Ohio; **Howard L. Marston,** the northwest with headquarters in Minneapolis, Minn.; **Robert L. Mallory,** the southwest with headquarters in Dallas, Tex.; **Robert B. Grant,** the Pacific and mountain region with headquarters in Los Angeles, Calif.; and **Lester W. Williams,** the Pacific northwest with headquarters in Portland, Ore.

"Tycol Apreslube cuts bearing failure... keeps production going at top speed"

That's correct! Tycol Apreslubes are extreme pressure lubricants that stand up under severe heat and moisture conditions, under tremendous loads. They inhibit rusting, and are highly stable.

Tycol Apreslube means lower lubrication costs... longer equipment service life... and positive protection against excessive gear and bearing wear.

For complete data, call or wire your nearest Tide Water Associated office.

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TIDE WATER ASSOCIATED OIL COMPANY

17 BATTERY PLACE - NEW YORK 4, N. Y.

SEND FOR A FREE COPY OF "TIDE WATER ASSOCIATED LUBRICANIA"

PUT UP TO STAY UP!

That's the statement of a midwest steel mill. Their letter continues: "We have in service GRID Unit Heaters Type No. 2500. A number have been in use for approximately 18 years on very severe service with steam turned on and off rapidly several times each day. Even under this severe service we have found them maintenance-free." There's the word of a mill operator who has proved that, with a GRID installation, first cost is last cost. Such service records (GRID installations made in 1929 are still operating) are the rule rather than the exception with GRID Unit Heaters because—

GRID is an all cast unit with finned heating sections and headers tested to withstand steam pressures up to 250# P.S.I.

GRID construction uses no brazed, soldered, rolled or welded connections between condenser and headers. A specially designed threaded nipple assures a precision, leakproof fit.

GRID construction has all similar metals in contact with steam thus preventing electrolytic corrosion which eventually occurs in copper type unit heaters where steam passes from iron pipes into copper cores. (Write for booklet CORROSION IN UNIT HEATERS).

GRID construction resists corrosion from corrosive acid fumes that exist in most steel mills.

GRID design incorporating low outlet temperatures, proper fan sizes and motor speeds, assures delivery of warm comfortable air in ample volume to the working level. No stratification of warm air at the ceiling to waste your fuel dollars.

EASTERN STAINLESS STEEL CORP. USES GRID BLAST COILS FOR SHEET DRYING. WRITE FOR CATALOG BC-1049.

These are the reasons why steel mill operators get 18 years and more of trouble-free service. There are units cheaper than GRID, but there is none better.

You start saving money the day you install GRID Unit Heaters. Get the complete GRID story. Write for catalog CUH-846-A.

REPRENTATIVES IN PRINCIPAL CITIES

D. J. MURRAY MANUFACTURING CO.

MANUFACTURERS SINCE 1883

WAUSAU, WISCONSIN

Harold T. Sawyer has been appointed manager of industrial products sales in the engineering products department of RCA Victor. Mr. Sawyer, who has had wide experience in engineering, sales, and service work with the General Electric Co. and the Bailey Meter Co., of Cleveland, Ohio, will be in charge of RCA's varied line of industrial equipment, including the electron microscope and other scientific instruments, beverage inspection machinery, metal detection equipment, and industrial television.

D. C. Shaw, III, formerly assistant secretary, has been promoted to secretary of Rust Engineering Co., Pittsburgh, Pa.

Paul E. Shroads, vice president of National Steel Corp., Pittsburgh, Pa., will assume the duties of treasurer, the position formerly held by **F. M. Hesse** who died last July 10. Mr. Shroads will continue to hold the office of vice president. **Charles G. Tournay,** treasurer of the Weirton Steel Co., Weirton, W. Va., will succeed to the positions of comptroller and assistant treasurer formerly held by Mr. Shroads. Mr. Tournay will be succeeded as treasurer of the Weirton Steel Co. by **Floyd T. Bowen,** who is now assistant treasurer.

H. W. Petty was named sales manager of R. E. Uptegraff Mfg. Co., Scottdale, Pa. Mr. Petty, who will maintain offices in Pittsburgh, Pa., formerly was manager of the company's Pittsburgh sales office. Mr. Petty joined Uptegraff in 1950 after serving for two years as Pittsburgh district manager for Carbone Corp. Prior to that he had been with Wagner Electric Corp. for 21 years, where he served as branch manager in Pittsburgh, Buffalo and Boston, and as a transformer specialist in Philadelphia and Cleveland.

A. W. Payne's retirement as chairman of the board of directors of Crane Packing Co., Chicago, Ill., after more than 30 years active participation, has been announced. **Frank E. Payne,** formerly president of the company was elected chairman and **Karl V. Rohlen** succeeded to the presidency from his former position of vice president and general manager.

H. B. PHILLIPS

H. B. Phillips has been appointed sales manager, quantity sales division of Cutler-Hammer, Inc., Mil-

How TIMKEN® bearings pay off on new pay-off reel

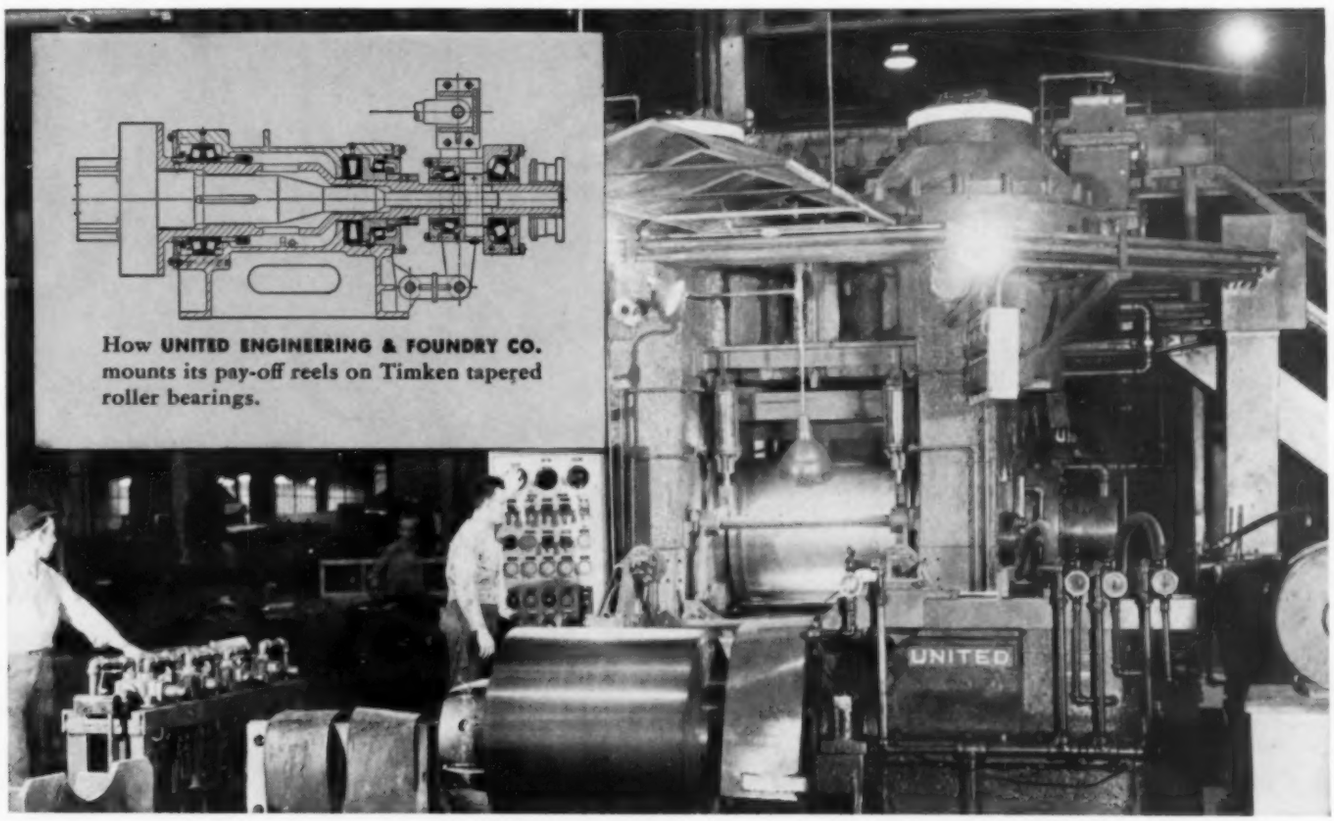
THIS new-design United pay-off reel operates at 5,000 feet per minute. To keep it on the job at this high speed and to take the heavy combination loads involved, design engineers specified that the reel be mounted on Timken® bearings.

Because of line contact between rollers and races, the Timken bearings have extra load-carrying capacity. Their tapered construction enables them to take both thrust and radial loads or any combination. The shaft is held in proper alignment. And because of incredibly smooth surface finish and true rolling motion, friction is practically eliminated.

Closures are more effective, too, because the Timken bearings keep housing and shaft concentric. Dirt and grit are kept out, while lubricant is kept in. Danger of fire hazard due to oil leakages is eliminated. Maintenance and lubrication time is cut to a minimum.

Over 50 years of bearing research and development have made Timken tapered roller bearings first choice throughout industry. Make sure the bearings in the machines you build or buy are stamped with the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How **UNITED ENGINEERING & FOUNDRY CO.** mounts its pay-off reels on Timken tapered roller bearings.

FINISHED TO CLOSER TOLERANCES

Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at the Timken Company.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST →◫← LOADS OR ANY COMBINATION →◫←

CLEAN WATER IN YOUR PLANT

Prolongs the working life span of all equipment that is cooled, heated or actuated by water.

Adams Poro-Stone filters convert your turbid supply to water of any degree of clarity you require. Used with or without filter aid, operated manually or automatically, Poro-Stone filters may be spotted throughout the plant at points of need or centrally installed for plantwide distribution.

Complete, packaged Adams filtration plants include filter aid precoat tank, continuous filter aid feeder, pressure backwash system, pump, valves and piping.

WRITE FOR BULLETIN 691

R. P. ADAMS CO., INC.

223 E. PARK DRIVE, BUFFALO 17, N. Y.

BROWNING MILL TYPE CRANES have *Plenty of Strength* WHERE STRENGTH IS NEEDED!

Browning Mill Type Cranes are built in accordance with A. I. S. E. specifications. They incorporate the types of motors and controls on which your mill or industry has standardized. This flexibility adapts your VRB crane *perfectly* to your needs. Only the finest materials are employed. Browning heavy duty cranes meet the most rigid demands and satisfy the most critical users. Our design, placing plenty of strength wherever needed, is the outgrowth of 48 years' experience in the crane industry.

Write for our Bulletin "E".

"Built as you yourself would build them"

VRB

VICTOR R. BROWNING & COMPANY, Inc.
BOX 309, WILLOUGHBY (CLEVELAND), OHIO
Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

waukee, Wisc. **F. A. Wright** has been named sales manager, district sales and **J. M. Cook** has been appointed sales manager, industrial control divisions.

F. A. WRIGHT

J. D. Swain and **E. H. Mangan** have been appointed executive vice presidents of Electro Metallurgical Co., a division of Union Carbide and Carbon Corp., New York, N. Y. Both Mr. Swain and Mr. Mangan have been with Union Carbide for many years, Mr. Swain having been associated with sales activities, and Mr. Mangan with engineering, power, and production.

George N. Landis has been appointed chief electrical engineer of the newly created electrical department of Hydropress, Inc., New York, N. Y., and its Loewy Rolling Mill Division. Mr. Landis has been connected with the organization since 1942.

J. M. COOK

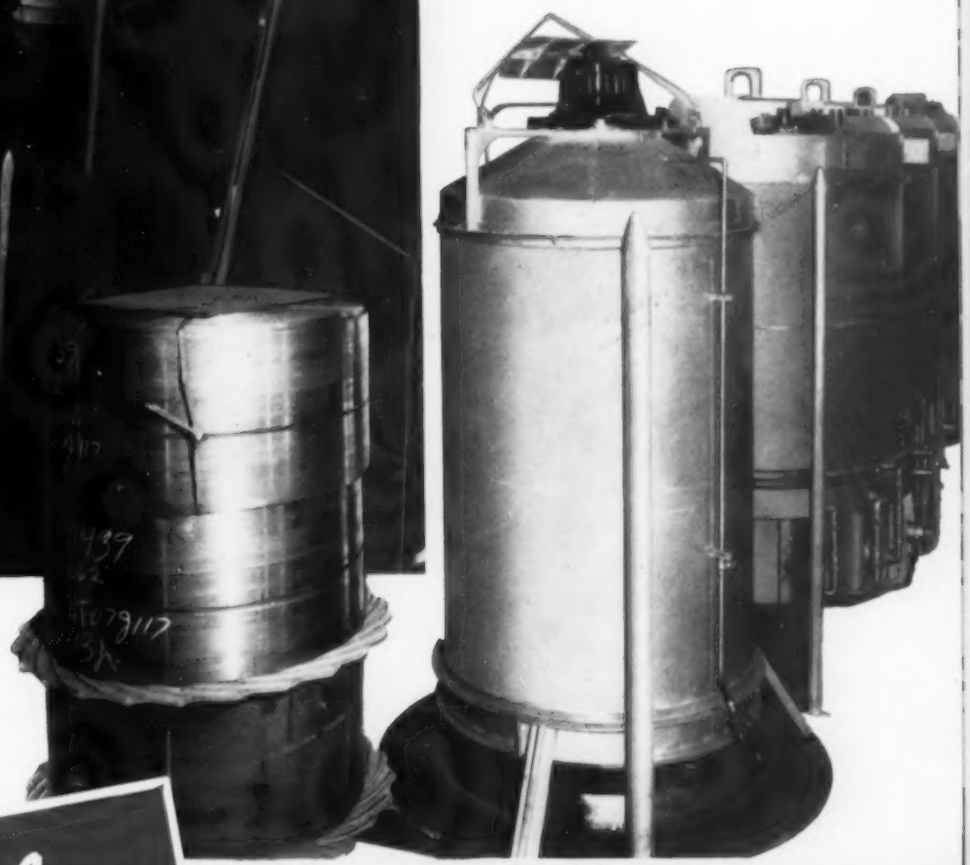
Richard H. Clay was named manager of the engineering service department at A. M. Byers Co., Pittsburgh, Pa. Mr. Clay has been associated with the Byers Co. for the past two years.

Robert L. Hanson is now a manufacturers agent in the Pittsburgh district for: DuBois Engineering and Manufacturing Co. of Hammond, Ind.; Sittler Corp. of Chicago, Ill., and Nepo Mfg. Co., Chicago, Ill. Mr. Hanson has had extensive industrial experience with Wagner Electric Corp., Crocker-Wheeler Co., Sperry Corp., and Allen-Bradley Co.

WILSON *single-stack*

convector annealing furnace

This fine new installation of Lee Wilson single-stack convector annealing furnaces is installed at the Sharon Steel Corp., Sharon, Pennsylvania. It comprises 3 furnaces and 9 bases, with a charge size 60" diameter, 120" piling height.



The key advantage of the single-stack convector furnace is annealing steel coils to the highest uniformity of metal structure in the shortest time.

Lee Wilson **ENGINEERING** *Co., Inc.*

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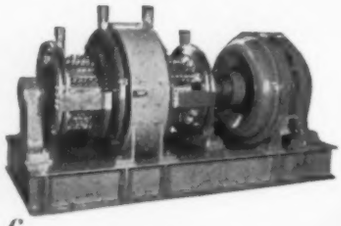
Telephone ED-1-6600

BELL TYPE FURNACES ★ RADIANT TUBE HEATING ★ ANNEALING PROCESSES

COLUMBIA

MOTOR GENERATORS



for • Electroplating
• Anodizing
• Electrocleaning
• Electropolishing

TONG TEST
A.C.—D.C.
AMMETERS

• TANK RHEOSTATS
• REVERSING SWITCHES

Write for Descriptive Bulletins

COLUMBIA ELECTRIC MFG. CO.
4543 HAMILTON AVE. CLEVELAND 14, OHIO

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FALCON HAS BEEN IN THE BUSINESS OF CUTTING YOUR OPERATING COSTS

It starts to happen immediately, like this, when you call on FALCON for Non-Ferrous Castings

FROM THE TOP on down, Falcon is a relatively small, shirt-sleeve organization of specialists. Regardless of title, the management man who takes your order PERSONALLY guides it into immediate action. And he stays on top of it until final delivery, USING his technical knowledge to assure both flawless quality of production and record service. It's a routine that protects Falcon's long-time reputation for best quality, best delivery. And it cuts your operating costs by eliminating delays and downtime due to imperfect casting practice.

FALCON

COPPER
Valve Seats
Valve Gates
Inwall Plates
Bash Plates
Tuyeres
Coolers
Monkeys

COPPER AND BRONZE CASTINGS

LICENSED MAKERS OF ALL PATENTED DESIGNS DEPENDABLE FOR 62 YEARS • SINCE 1890

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YOUNGSTOWN 3, OHIO
Established 1890 - Incorporated 1895

Robert P. Kloeckner was appointed sales representative for the Fageol Heat Machine Co., Detroit, Mich. Mr. Kloeckner, formerly district sales manager for the fan division of Robbins & Myers, Inc., Memphis, Tenn., will handle distribution and sales of the Fageol Heat Machine in Illinois, Wisconsin and Minnesota. His headquarters will be in Chicago.

Duncan A. Black has been named manager of the newly combined Power Piping and Sprinkler division of Blaw-Knox Co., Pittsburgh, Pa. Since the beginning of 1949 he has been vice president of the Blaw-Knox Construction Co., a subsidiary, and assistant manager of the former Power Piping Division.

Robert G. Brossard has been appointed sales agent in the American Car and Foundry Co.'s New York, N. Y., district office. Mr. Brossard was formerly with American Car and Foundry in Cleveland, Ohio.

P. M. Buhrer and **C. O. Kleinsmith** have been appointed executive vice presidents of National Carbon Co., a division of Union Carbide and Carbon Corp., New York, N. Y. Both Mr. Buhrer and Mr. Kleinsmith have been with National Carbon Co. for many years, Mr. Buhrer having been associated with research and development activities and Mr. Kleinsmith with sales.

Wynn T. Sullivan has been appointed advertising manager of Heyl & Patterson, Inc., Pittsburgh, Pa. Before joining Heyl & Patterson Mr. Sullivan was associated with the Penton Publishing Co., Cleveland, Ohio, where he engaged in market research and promotion activities.

C. Wesley Merritt has been named sales manager of the newly organized railroad department of National Electric Products Corp., Pittsburgh, Pa. Mr. Merritt has been with National Electric since 1940.

H. J. Leaver was appointed as assistant to the president of Treadwell Engineering Co. Mr. Leaver will be located at the Easton, Pa., plant. Mr. Leaver was associated with the American Steel & Wire Co. in various positions until 1949. Since 1949 he has served as staff engineer—rolling mills with the Jones & Laughlin Steel Corp., Pittsburgh, Pa.

William J. Mullaney has joined Fischer and Associates, consulting engineers, 5209 Euclid Ave., Cleveland, Ohio, as contract engineer. Mr. Mullaney has been associated with the Austin Co. as power engineer, and with H. K. Ferguson Co. as staff mechanical engineer. His most recent assignment was with the Bechtel Corp. in San Francisco, Calif.

William K. Sonnemann has been named manager of the relay engineering section of the Westinghouse Meter division. Mr. Sonneman has been serving as a relay design engineer.

R. S. Stevenson was elected executive vice president of the Allis-Chalmers Manufacturing Co., Milwaukee, Wisc. Mr. Stevenson, before he was elected to this company-wide post, was vice president in charge of the tractor division.

C. E. Wise, founder and owner of Wise Equipment Co., Detroit, Mich., died June 14.

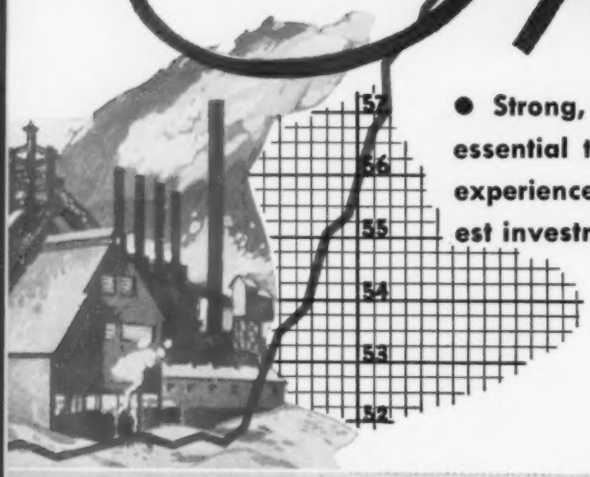
TRANTINYL

guides the steel industry

YOUNGSTOWN ALLOY CASTING CORP., • YOUNGSTOWN, O.

ROLLING MILLS: bar, hoop, strip, shape mill guides, and rollers. SEAMLESS TUBE MILLS: guide shoes, rolling mill plugs and rolls, piercer points, etc. ELECTRIC WELD TUBE MILL: forming rolls, planishing rolls, tool holders, etc. • STRAIGHTENING MACHINE GUIDES • HEAT RESISTING CASTINGS

Helping BOOST



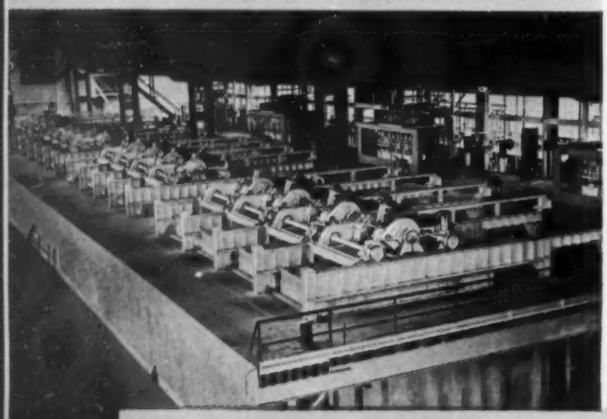
● **Strong, solvent steel companies in the hands of competitive industry are essential to America's prosperity and growth. Over a quarter century's experience has demonstrated that 'Surface' equipment is one of the soundest investments steel mills can make.**

● **MANY STEEL MILLS** will credit a growing list of Surface Combustion equipment with helping to improve production this year, and in the years to come.

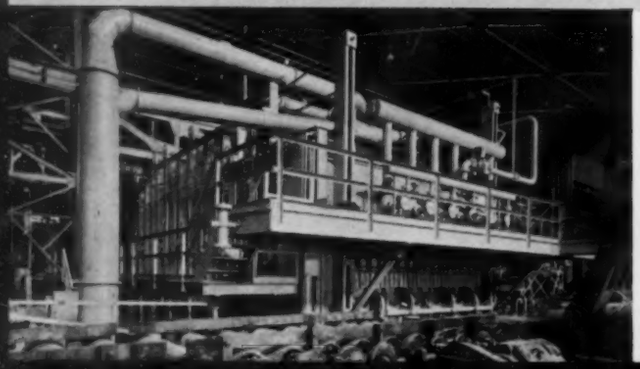
● **FIRST TO INTRODUCE** the venturi jet pump recuperative system, 'Surface' made the initial installation at a leading Ohio Valley steel plant in 1948. This system provides the optimum combination of thermal recuperation and precise ratio control. These jet pumps have since helped increase capacity and reduce costs in many other new soaking pit installations in America's leading steel mills.

● **SURFACE COMBUSTION EQUIPMENT**—with an unmatched record for operating and maintenance economies—has proved a most effective tool for steel mills in their continuous struggle to provide higher standards of production and quality. Some of the furnace equipment is shown here. Perhaps 'Surface' can help you, too.

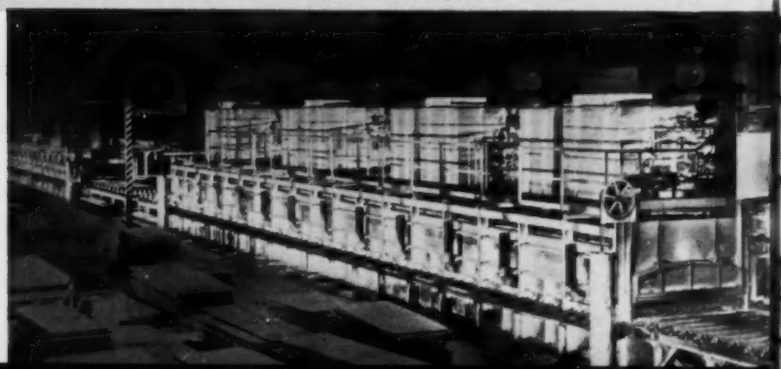
One-way fired soaking pits.



Slab heating furnaces.



Continuous armor plate heat treating furnaces.



SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

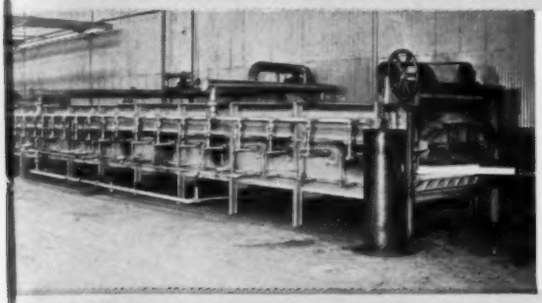
FOREIGN AFFILIATE COMPANIES

BRITISH FURNACES LIMITED—CHESTERFIELD
STEIN & ATKINSON, LTD.—LONDON
STEIN & ROUBAIX—PARIS, LIEGE AND GENOA
WILL L. SMITH, S.A.—BUENOS AIRES

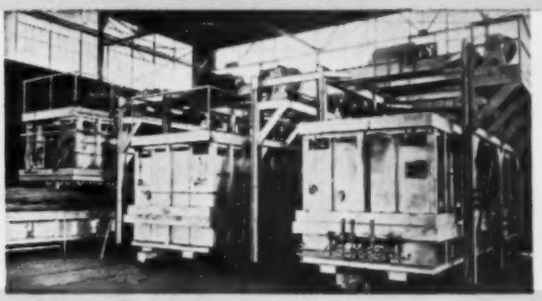
'Surface' A GREAT PRODUCTION NAME IN THE STEEL INDUSTRY

STEEL MILL PRODUCTION
in the critical 50's

Wire patenting furnaces.

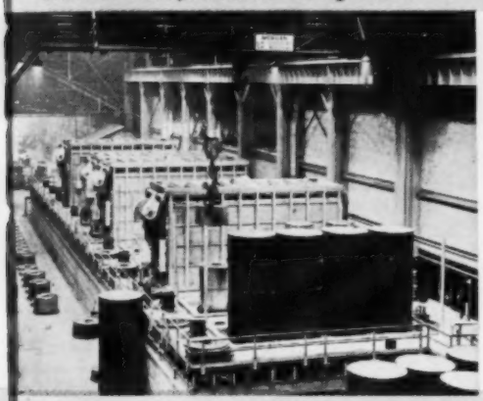


Batch type carbon correction annealing furnaces.

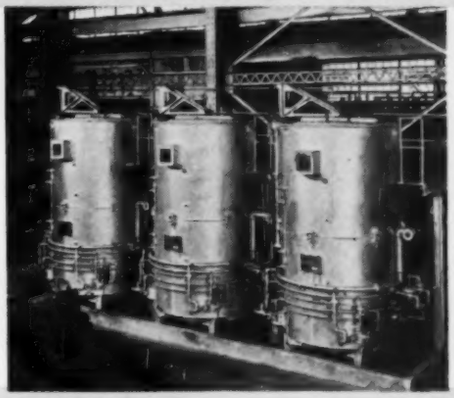


Continuous bright annealing and normalizing furnaces for tubing.

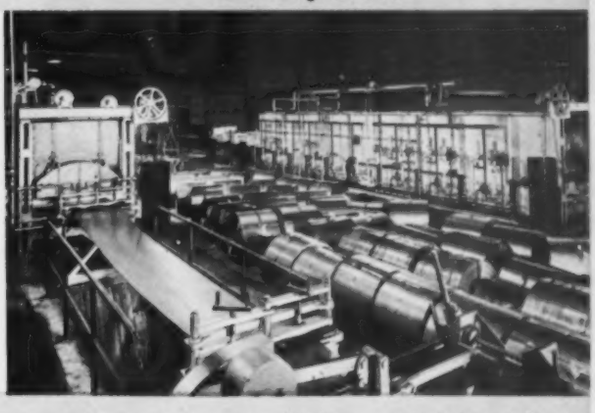
Controlled atmosphere coil annealing covers.



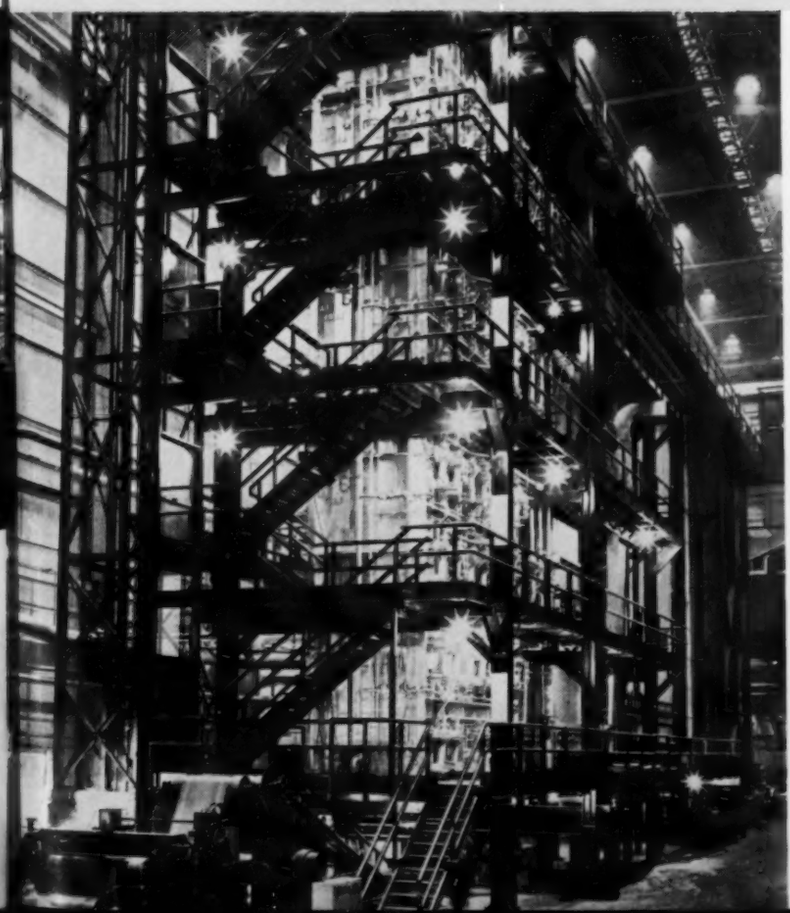
Pit type convection furnaces for rod annealing.



Continuous strip annealing and normalizing furnaces.

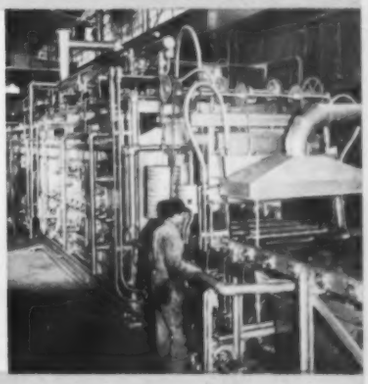


Continuous vertical strip annealers.

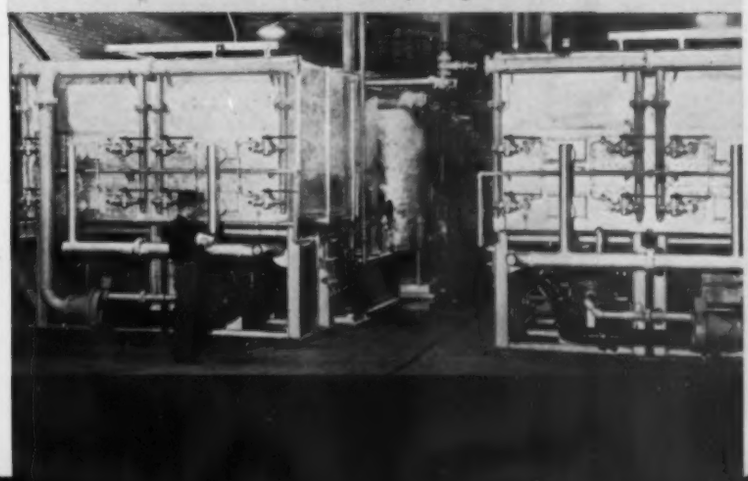


Stress relief furnaces.

Continuous controlled atmosphere annealing furnaces.



Prepared atmosphere generators.



26″ STRUCTURAL MILL

BUILT BY MORGAN Engineering

DESIGNERS • MANUFACTURERS • CONTRACTORS

BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS

ELECTRIC TRAVELING CRANES • CHARGING MACHINES

INGOT STRIPPING MACHINES • SOAKING PIT CRANES

ELECTRIC WELDED FABRICATION • LADLE CRANES

STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES

SPECIAL MACHINERY FOR STEEL MILLS

THE MORGAN ENGINEERING CO.

ALLIANCE, OHIO PITTSBURGH—1420 OLIVER BUILDING

Illustrated is a 26″ Three-High Structural Mill, consisting of one 26″ Three-High Pinion Stand connected to two Three-High Roll Stands and one Two-High Pinion Stand connected to one Two-High Finishing Stand.

For serving this mill, there was furnished four Traveling and Tilting Tables and four Traveling Trailing Tables.

Your inquiries for mill equipment will be appreciated.

Equipment News...

SHEET BEND TESTER

▲ Though the hand-bending of sheets has not been used as a test, operators, die-setters and quality control men know that the easier the steel is to bend, the better its drawability, and vice versa.

As a result of this observation the Flex-Tester was developed which by measuring resistance to bending gives an accurate measure of the drawing quality of cold-reduced sheet and strip steel. A spherometer, adapted to measure the diameter of the bend in the sheet is also used, giving an accurate determination of the material's susceptibility to stretcher strain during the draw.

Charles B. Buker, a Jones and Laughlin metallurgist, and John R. Speer, of the metallurgical research division worked over a year to develop the instruments.

In using the Flex-Tester, the operator bends back a corner of the steel sheet, and the resistance to the bend is measured on a dial on the Flex-Tester. After a large number of tests it was determined that, for severe draws, 60 on the gage is an approximate dividing line between steel that can be drawn satisfactorily and steel that might not take the draw.

The entire test takes less than a minute. In a stamping plant as many blanks as desired can be tested before drawing without destroying any of the material. Little training of operators is required. In order to get Flex-Tester readings that are corrected for thickness of the sheets, the operator needs only to use a micrometer, then refer to a conversion table.

Besides its application in stamping plants, the Flex Test can be used also in strip mills. A series of tests could be made along the length of the strip at the temper mill. With the mill stopped momentarily, an 8-in. slit would be cut in the edge of the strip with a hand shear, and the Flex Test readings taken.

Patent has been applied for on the Flex-Tester, and arrangements have been made with Steel City Testing Machines, Inc., 8843 Livernois Ave., Detroit 4, Mich., to make both the Flex-Tester and spherometer available to the public.

PLUG-IN CIRCUIT BREAKER

▲ A new hi-shock plug-in circuit breaker has just been introduced by the Trumbull Electric Department of the General Electric Co. In order to simplify installation and maintenance, Trumbull has also developed a unique sub-base for mounting this new circuit breaker.

Designated "K-173," the new breaker is designed primarily for the protection of three wire lighting systems. However, according to Trumbull product engineers, it can also be used for two wire systems by connecting the circuit to the two protected poles of the breaker. And it is suitable for overload and short circuit protection of load circuits supplying power to single unit consuming devices, such as radar, ordnance and electronic equipment.

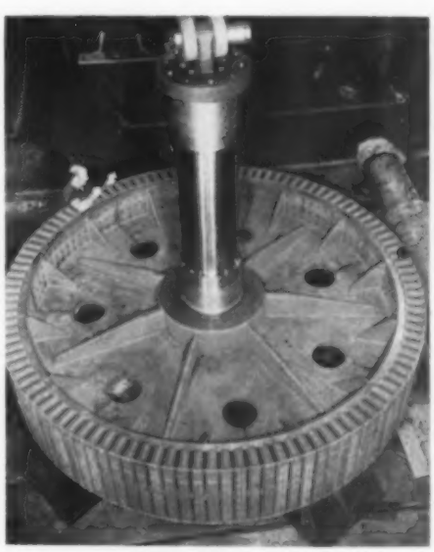
Rated at 125 volts a-c or d-c, with trip ratings from 10 to 50 amps, the circuit breaker can be used on any frequency system between 60 and 400 cycles and has an interrupting rating of 5000 amperes. In addition to being a small, compact, space-saving unit, the circuit breaker's plug-in features and the new mounting base allow for quick removal and replacement by the operator. This enables the operator to remove the breakers with minimum interruption of the system, by simply substituting a spare breaker for one that has been removed. The damaged breaker can be replaced without disconnecting a single line or load wire. All the operator does is remove the two mounting bolts, screw them into the inserts provided in the cover, grasp the bolts in both hands, and pull straight out. He then simply plugs a spare breaker into place, and inserts the mounting screws. In addition to Navy circuit breakers with trip ratings, Trumbull manufactures a non-automatic type for use as a small, compact hi-shock disconnecting or switching device. It is rated 50 amps, but does not offer overload protection.

Plug-in operation is achieved by means of female draw-out terminals, made of formed copper, which accommodate connecting stabs of corresponding dimensions. The sub-base, like the breaker case itself, is made of molded asbestos phenolic compound, formed and slotted to hold the silver-plated copper stabs. The base is shaped, and the stabs arranged so that incorrect mounting of the breaker is impossible.

The versatility of the new single

ROTOR

This photograph, taken in the Ridgway, Pa., shops of Elliott Co., features the rotor for a 2000-hp, 64-rpm synchronous motor. Diameter of rotor is 13 ft, the smallest possible for the number of poles — 112. In spite of its size, a ⅛-in. air gap is maintained in the actual motor, which is now driving a main rolling mill in a big tube mill plant. The motor is part of a change-over program in which the plant is modernizing and changing from 25- to 60-cycle current. Pole pieces are unusually long as compared with their width, these proportions being necessary to keep the diameter of the rotor within reasonable size.



sub-base is further demonstrated by the fact that the basic molded slabs can be used in pairs with suitable crossover and terminal straps as a double base assembly for close panelboard arrangement, permitting further space-saving. The single unit is generally used for individual mounting enclosures or in switchboard applications.

While these Trumbull circuit breakers and sub-bases were originally designed for Navy hi-shock shipboard conditions, their compact, rugged, hi-shock sustaining qualities make them well suited for marine applications, as well as for use in electronic and ordnance equipment, cranes, shovels, tractors, and other devices requiring back up or feeder protection.

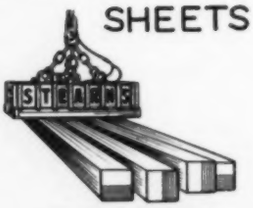
SAVE TIME SAVE LABOR

SCRAP

PIG IRON

ROUNDS

SHEETS


BILLETS

"Small Bite—Big Load"

LIFTING and transporting these two huge steel castings (each weighing 4000 pounds), is everyday work for this STEARNS Lifting Magnet at the Maynard Electric Steel Casting Co., Milwaukee. This 45" diameter circular magnet is one of a team of STEARNS Lifting Magnets used throughout the cleaning room and foundry whenever castings have to be moved — doing the job efficiently and economically year in and year out.

If you handle castings, borings, turnings, pig iron, strip steel, rails, slabs, billets or scrap iron, there's a STEARNS Lifting Magnet EXPERIENCE ENGINEERED to help you save time and money. For the efficient handling of flat steel sheets, plates and bars, be sure to investigate STEARNS Rectangular Lifting Magnets.

STEARNS Lifting Magnets are available in standard sizes in both bolted and all welded constructions. Special sizes and shapes made to meet your requirements.

Write today for complete specifications and operating data.

Foremost in the Magnetic Field

Stearns MAGNETIC INC.

681 South 28th St., Milwaukee 46, Wis.

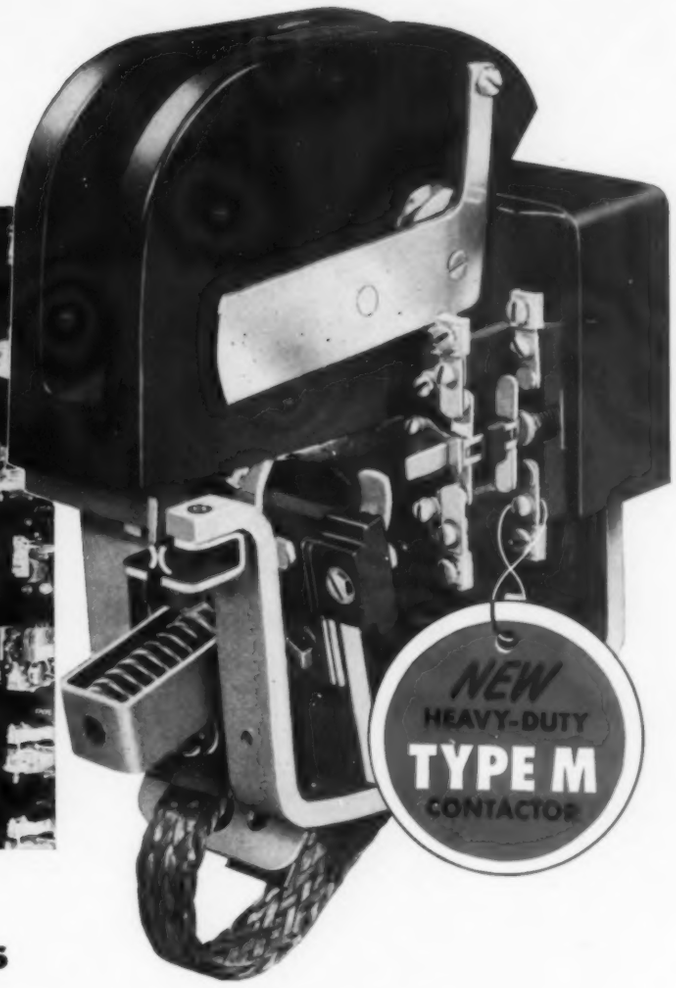
CENTERING REELS

▲ Now being produced by F. J. Littell Machine Co., Chicago, Ill., are extra heavy duty automatic centering reels in 5, 10 and 20 ton capacities.

Throughout industry the trend toward larger and larger coils has dictated the development of more efficient handling equipment. Experience in the field with heavy coils has proven the advantage of the spindle type reel over the cradle or coil box type for handling thin stock. The spindle type completely eliminates rolled over edges and damaged surfaces formerly encountered when coil was tumbled in the coil box. The improvement in production and savings resulting from better finishes and elimination of material losses, together with the savings in manpower, labor and down time make this equipment of considerable interest to all production men concerned with fabrication from coils.

These reels have hydraulically expanded arms which are contracted and expanded by means of hydraulic actuated cams within the spindle. As the spindle sleeve is hydraulically pushed forward, the arms contract to the minimum diameter. As sleeve is pulled toward the frame, the arms spread until the coil is gripped tightly. The cams on the sleeve and on the arms are mechanically interlocked to hold arms in position, both expanded and contracted. The simultaneous expansion of the arms perfectly centers the coil.

The V-type coil-loading car rides on a smooth running track base. The track can be extended from machine to coil storage area, hence material



10 Years of Make-Breaks

Prove TYPE M Dependability

on Weirton Steel's Tin-Plate Line

If dependability and trouble-free operation interest you, here's a contactor worth knowing about. It's new—yet proved by ten years on-the-job testing.

Back in 1941, Westinghouse looked for the toughest applications to field test these contactors . . . picked locations for their severe duty. On numerous applications in five mills throughout the country, Type M Contactors went to work to prove themselves the most dependable yet developed.

One example was the first Tin-Plate Line constructed at Weirton Steel Co. Here, Type M's meet all Weirton's demands for dependability, low maintenance and long life. In fact, the successful operation justified using them in many other applications such as Shearing, Cleaning and other Plating Lines.

Millions of make-breaks proved the Type M dependability to Weirton Steel. You can prove it yourself. Ask your Westinghouse representative for full details on this contactor. Check the unit construction . . . unit mounted interlocks, "Qwik-Quench" arc box, and knife-edge bearings. Ask him today for a free copy of B-5261 and the complete Type M story. Or write Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Pennsylvania. J-27013

YOU CAN BE SURE...IF IT'S
Westinghouse

MOTORS and CONTROLS

can be conveyed to reel without intermediate handling.

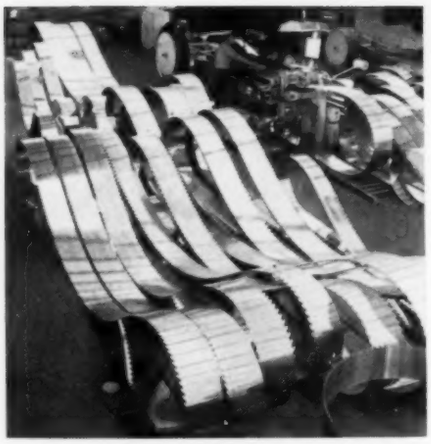
The Littell Co. makes a complete line of handling equipment such as reels, roll feeds and straighteners for coils of 100 lb to 40,000 lb.

BAND-SAW WELDING

▲ These recently completed 50-ft endless band-saw blades, shown awaiting shipment from the Simonds Saw and Steel Co., Fitchburg, Mass., were joined together with General Electric atomic-hydrogen welding equipment.

According to Simonds engineers, a 50-ft band-saw in use travels at express-train speed and bends as often as 440 times a minute. Thus, even normal operation subjects it to the severest test and any weakness in steel or joints will cause the saw to snap and fly apart.

To avoid this, Simonds makes its own saw steel from selected melting



stock and alloys. In joining the band saws, some as long as 60-ft and as wide as 16 in., Simonds uses its own specially-made filler rods in conjunction with G-E atomic-hydrogen welding. This method, the engineers said, has been found to be the best process yet tried, and they have been using it successfully for the last seven or eight years. During that period, not a single report has been received of a weld breaking while a saw was in operation.

FUEL OIL SYSTEMS

▲ The Rust Furnace Co. will construct two complete fuel oil handling systems to serve the new Fairless Works' pipe mill of National Tube Division, United States Steel Co. at Morrisville, Pa.

The contract involves design, engineering and erection of facilities for

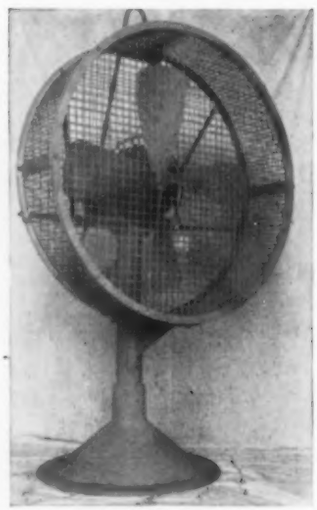
LOAD CARRIER

New extra-heavy-duty load carriers, in capacities up to 36,000 lb, are available from Yale & Towne Manufacturing Co. The trucks are designed to handle large, bulky industrial loads such as crated machinery from assembly and crating areas to shipping docks and railroad sidings. Loads are placed on the truck and removed by fork trucks or cranes. The truck features four-wheel power steering for ease of operation and maneuverability. Where extra-large loads are handled, the driver can turn around and drive the truck backwards for better visibility.

IS HEAT SLOWING UP YOUR WORKMEN?

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS



Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

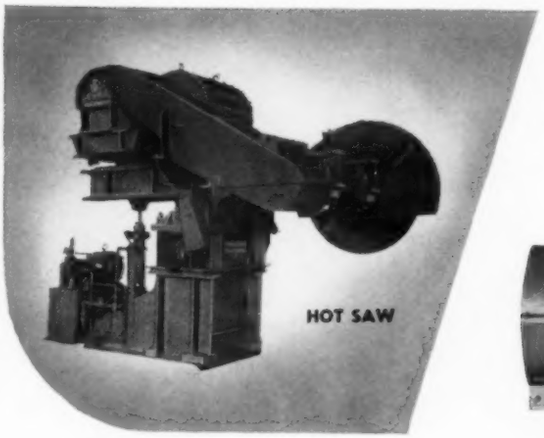
PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY

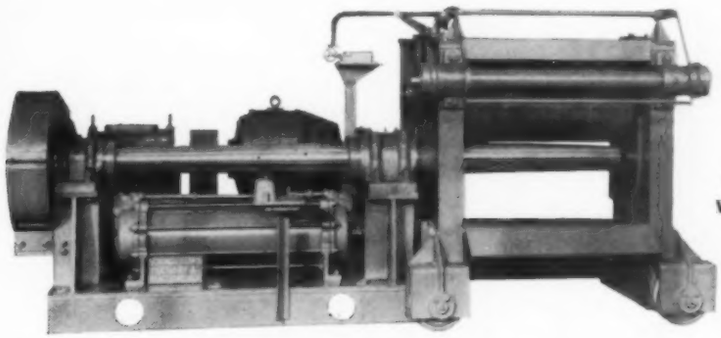
245 MAIN ST., HARMONY, PA.

F&Y BUILDS *MODERN MILL EQUIPMENT*

designed to do a better job



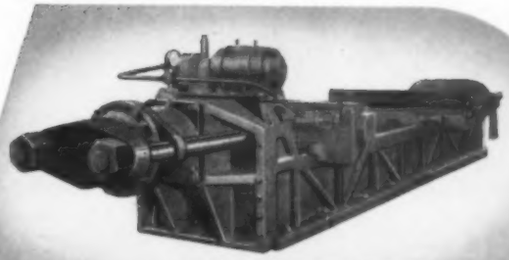
HOT SAW



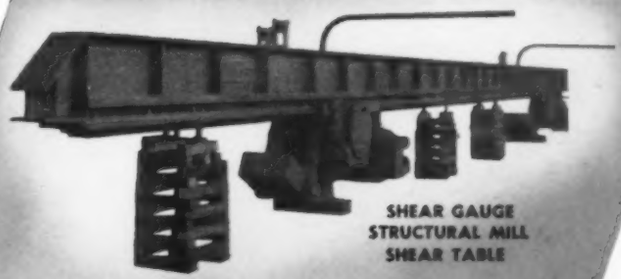
SCRAP WINDER

Products of Proven Performance

- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—Traveling and Lifting Tables
- Continuous PICKLING Lines—ROLLER LEVELERS
- FURNACE Charging Equipment—Furnace Pushers
- Strip Steel COILERS and REELS—SCRAP BALLERS
- RAILROAD Spike Forming Machines—ROLL LATHES
- Sheet GALVANIZING Lines—Wire Patenting Frames
- Stretcher Levelers—Angle and Shape Straighteners
- Rolling Mill Tables—Gear and Individual Motor Types
- PARALLOY ROLLS (Pinch, Coiler, Tension, Steel Mill)
- DUCTILE CASTINGS (80,000 PSI.)



800,000# STRETCHER LEVELER



SHEAR GAUGE
STRUCTURAL MILL
SHEAR TABLE

PARALLOY ROLLERS

Machinery Built to Customers Design and Detail Drawings

The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

7*

unloading, storage, conditioning, and recirculating of the pipe mill's fuel oil supply. Included are facilities for fire protection by foamite piping.

Light fuel oil will be handled by one system and bunker C fuel oil by the other. Plans call for tank storage of some 300,000 gallons of the bunker C, and 1,000,000 gal of the light fuel oil.

CHARGE INDICATOR

▲ To help obtain greater efficiency and maximum economy with industrial truck batteries, Gould-National Batteries, Inc., announces a new and improved charge indicator.

The instrument can be easily mounted so that the operator can see the dial at all times, thus giving him instantaneous readings of the state of battery charge while his truck is operating. An easy-to-read, three-colored dial indicates whether the battery is "full," "½," "empty," or in "danger." Changing batteries as soon as they register "empty" prevents repeated overdischarge which shortens battery life.

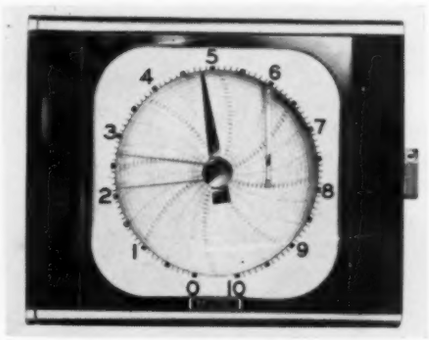
The indicator, a Wheatstone bridge type instrument, is readily adjustable for 3, 6, 12, 15, 18, and 24-cell batteries; a series of resistors and taps permits the desired adjustment. It is completely enclosed in a metal case finished in black, crackle enamel. The meter is balanced to read accurately regardless of its mounting or the truck's position. A toggle switch disconnects the indicator from the battery during charge.

The indicator is available for immediate delivery and carries a 90-day guarantee.

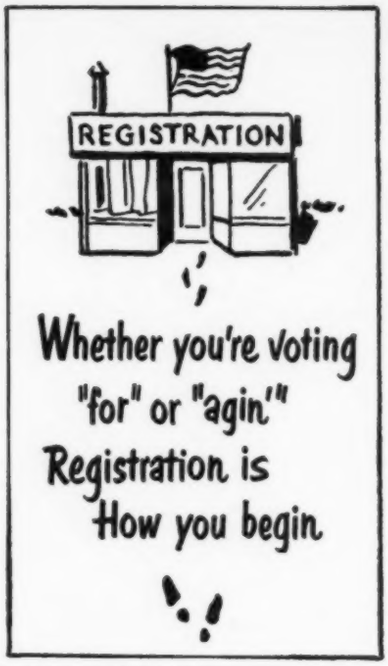
ROUND-CHART RECORDER

▲ Bristol Co. announces the addition of round-chart recorders and automatic controllers to its line of electronic "Dynamaster" potentiometers and bridge instruments. The new round-chart models are accurate, high-speed, continuous-balance, null-type electronic instruments which can be used to measure any variable that can be translated into an electrical quantity such as d-c current, d-c voltage, capacitance, or resistance. Typical sensing elements that can be used with the new instruments include thermocouples, radiation detecting units, resistance thermometer bulbs, pH amplifiers, tachometer magnetos, strain gauges, smoke density detectors, thermal converters for power measurements, beta ray gauges, and many others.

The measured variable is simultaneously recorded on a 12-in. diameter chart and indicated on a large circular scale which is legible at a distance. Models are offered for full-scale pen travel in 7 seconds, 3 seconds, 1½ seconds, or ⅔ second, and with a wide variety of ranges. Controlling models with all types of air control and electric control action are also available.



The new round-chart instruments feature the same design, construction and electronic components as the company's strip-chart instruments. The unit universal construction permits complete interchangeability of components. The recording mechanism is on the front of a hinged aluminum alloy panel, which can be swung out to gain easy access to the electronic components.



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Shaker conveyor moving hot castings and mold sand to shakeout.

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4. Maintenance cost is low; continuity of operation is high.

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Plate handling cranes by "Shaw-Box" are ruggedly built to exacting standards of fine engineering and workmanship that give you reliable, trouble-free lifting performance and dependability, with a minimum of attention under the most severe operating conditions. They include exclusive features such as variable flux control, lifting magnets that discharge one plate at a time after picking up several, rope lifts with guides to restrict swing, and many other advantages for fast operation at the lowest costs.

For many years, the building of steel mill cranes has been an important part of "Shaw-Box" operations. Each one traditionally includes the most advanced design and construction techniques that insure high efficiency, low-operating costs, and exceptional maintenance convenience. Each is an outstanding example of the complete interpretation that can be made of individual mill or AISE specifications, without requiring a price premium.

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"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

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Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, and 'American' Industrial Instruments.

GRAPHITE BAR STOCK

▲ The Steel and Tube Division of Timken Roller Bearing Co. announces a new graphitic steel product which will carry the trade name "Graph-Mo Hollow-Bar." This new product is a turned and bored bar section using for the basic material the familiar "Graph-Mo" tool steel which Timken has been marketing for more than 15 years.

This new product will have all of the advantages of graphitic-type tool steel plus the convenience of the hollow bar section in manufacturing ring gages, dies and other annular tool steel parts.

The material will be stocked in fifteen cities throughout the country and it is planned to have initial stocks ready for distribution in September of this year. Stock sizes will range from about 4 in. to 16 in. outside diameter with a variety of wall thicknesses. Present distributors for "Graph-Mo Hollow Bar" are A. Milne and Co. and Peninsular Steel Co. Stocks will be located in New York, N. Y., Boston, Mass., New Britain, Conn., Philadelphia, Pa., Buffalo, N. Y., Pittsburgh, Pa., Cleveland, Akron, Dayton, Toledo, Ohio, Detroit, Grand Rapids, Mich., Indianapolis, Ind., Chicago, Ill., and San Francisco, Calif.

PRESERVATIVE OIL

▲ The internal combustion engine which is temporarily taken out of service for purposes of storage or shipment presents a special problem. It must be properly lubricated for service preceding or following the stand-by period, and it must be protected against rust and the acidic products of combustion while it is not being used. In the past it has been necessary to accommodate these separate needs with separate products. The lubricant was drained from the engine and a preservative put in, and vice versa, depending, of course, upon whether the engine was going in or out of service.

Extensive research covering all aspects of this problem has resulted in the development of a new dual-purpose product by the Port Neches, Tex., laboratories of Texas Co. Produced in two grades, "Texaco" preservative oil 10, and 30, functions both as a lubricant and as a preservative. It eliminates the need for handling two products successively. The time which is saved is a critical consideration in the instance of military vehicles being shipped to an area where they may have to "come out fighting."

Research experts of this company carried out long-range investigations into such factors as humidity, condensation, corrosion, and related phenomena. The resultant product combines special additives developed to ensure maximum preservation of internal engine surfaces with motor oil additives of the type used in heavy duty lubricants. The preservative oils 10, and 30, incorporate characteristics which in some instances exceed by five-fold the requirements of military specifications. For example, one test requires that steel panels, which have been dipped in preservative oil, should remain free of corrosion after 200 hours' exposure in a humidity cabinet at 100 F and 95-100 per cent relative humidity. The new Texaco formulation gave protection for more than 1,000 hours.

In addition to its application in the engines of vehicles scheduled for storage or shipment, the new lubricant-preservative has proved useful in other internal combustion engines in intermittent service. Examples of the latter are stationary engines and engines in farm vehicles. Preservative oils 10 and 30, when functioning as a lubricant need not be changed until the engine has reached the normal drain-and-refill point. It is compatible with qualified heavy-duty motor oils.

SLITTING LINE

▲ A new type slitting line, adaptable for use by strip steel producers or fabricators has been developed by Herr Engineering Co. of Warren, Ohio. This precision rotary slitting line has many new and exclusive features which are claimed to provide greater speed, easier operation, more

THERMIT WELDING
Speeds PUNCH to Steam Hammer

Serious losses in production threatened a large mid-western forging company, due to long delays in obtaining forgings the size of a complete 35,000 lb. ram. It was, therefore, decided to manufacture the ram for a steam hammer by joining two smaller forgings with Thermit Welding (Fig. 1) . . . a job which took only two weeks. The fabricated ram has seen many months of severe service (Fig. 2), and based on its excellent record, others are being built in the same way.

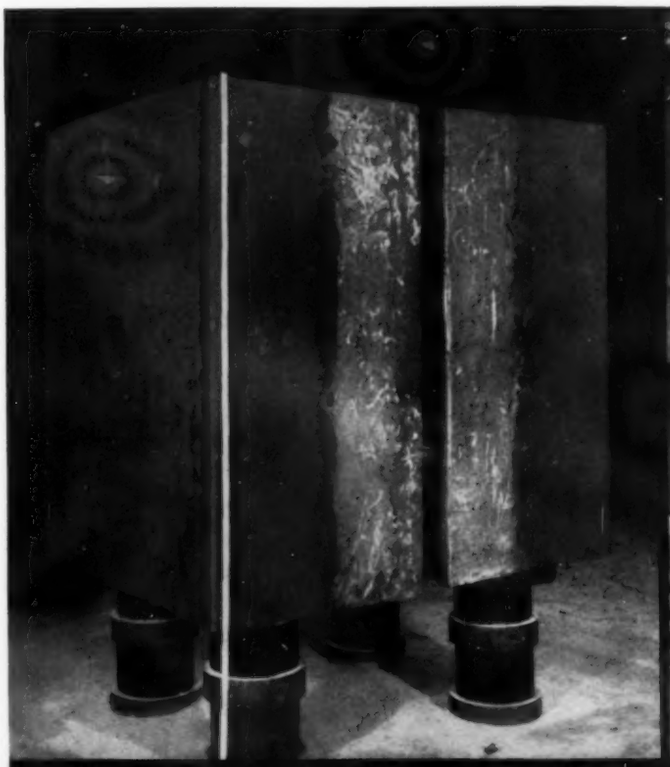

Fig. 1—Two forgings for ram in position prior to Thermit Welding.

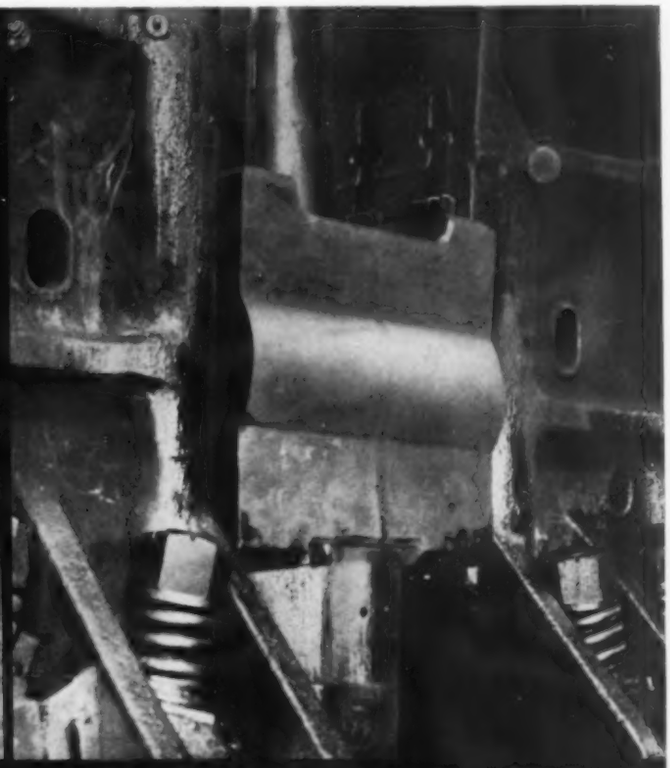

Fig. 2—Finished 35,000 lb. ram after fabrication by Thermit method.

CONSISTENTLY SOUND WELDS . . . MINIMUM OF TECHNICAL SKILL NEEDED . . . SPEEDY REPAIRS . . . LOWER THAN REPLACEMENT COSTS—four hard-hitting reasons for the swing to Thermit Welding in the repair, manufacture and maintenance of heavy drop forge industry equipment. Contact M&T on how Thermit Welding can help you!

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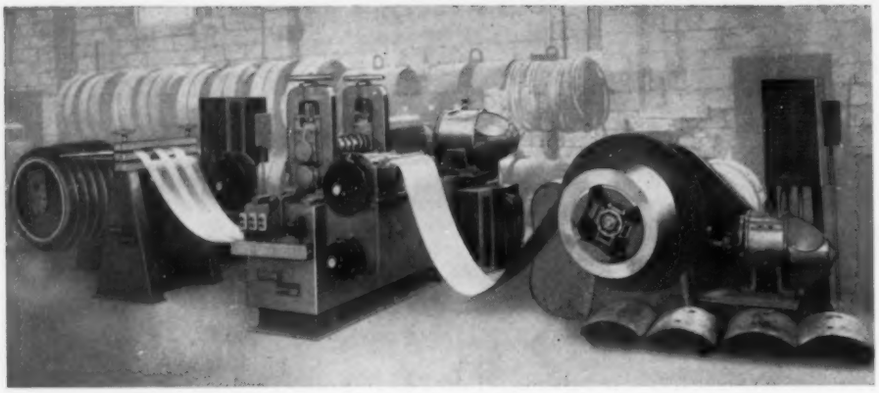

flexible control and increased economy of production.

In designing the Herr precision slitter considerable study was given to provide the greatest amount of convenience and comfort for the operator. For example, the base of heavy welded steel construction incorporates a channel section around the bottom which permits the operator to work close to the machine without stubbing his toes.

Another item of operator convenience is provided in the design of the outboard housing which can easily be pulled away from the arbors to permit cutter changes by turning a hand crank. By means of ways and a jack screw this operation is effected easily and smoothly without disturbing the bearings in the housing or exposing them to dust and dirt as these bearings are protected by a sleeve interposed between them and the arbor.

Another feature that simplifies operation is the use of two adjustment screws for the entrance guides. One removable crank regulates the guides to the width of material being fed and another crank regulates the centering of the material. Once the width adjustment is made at the beginning of the coil only the operation of one crank is needed to insure even scrap on both sides.

An outstanding feature of the slitter is the use of removable gibs for easy removal of the chocks carrying the top arbor bearings. Up and down adjustment of the chocks is accurately and easily made by means of handwheels. A handy dial indicates clearly the amount of the adjustment. A replaceable bronze nut is used on these adjusting screws and a locking spanner nut is provided to take up play. Further compensation for wear is provided by shims fitted under the gib clamp.

Patent application has been made for this ingenious removable gib with clamp adjustment which contributes to ease of maintenance and provides for continuing accuracy through long years of wear.

The standard precision slitter will handle material up to .125 in. thick, but it also can be adapted as a driven slitter to handle material as thin as .001 in. This ability to handle extremely thin material with accuracy and trouble-free operation is one of the important advantages of this slitter. Custom built lines can be supplied to handle any size, width or kind of material.

USE THE ENGINEERING MART

Is your washing machine cleaning brass, aluminum and zinc die castings as well as it cleans steel? Do the nozzles clog too often? Is there too much foaming?

Oakite has developed cleaning materials that meet every requirement for washing metal in every type of machine.

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¶ How to prepare metal for painting. *See page 9.*

¶ Tips on selecting and operating washing machines. Special instrument aids to better operation. *See pages 10 to 13.*

FREE For a copy of "*8 things to look for when you wash metal by machine,*" write to Oakite Products, Inc., 19 Rector St., New York 6, N. Y.

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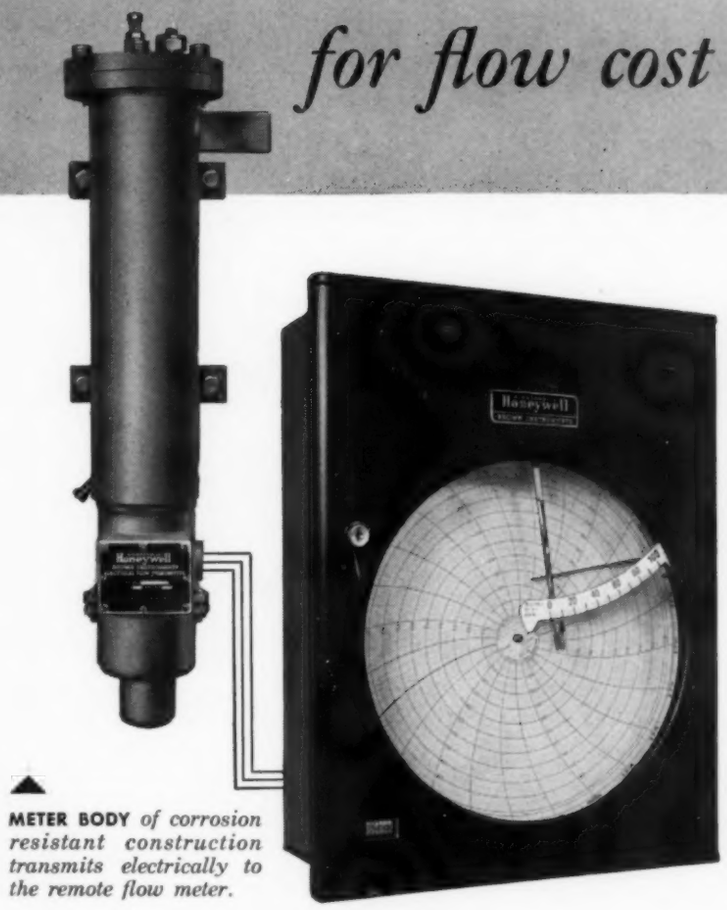
INDOOR & OUTDOOR LIGHTING FOR EVERY NEED

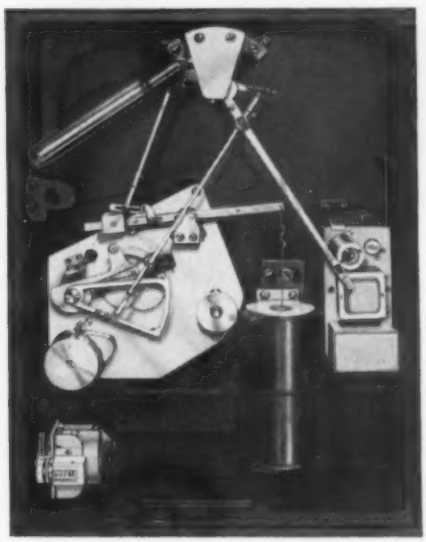
New evenly graduated flow meter *for flow cost accounting*



METER BODY *of corrosion resistant construction transmits electrically to the remote flow meter.*

FLOW METER *with evenly divided chart is uniformly accurate . . . easy to read at all rates of flow.*

ELECTRONIC INTEGRATOR *is fast, accurate . . . eliminates slow, complicated totalizing . . . simple to service.*



AN IMPORTANT development in flow instrumentation—the Brown Evenly Graduated Flow Meter—brings new accuracy and convenience to flow cost accounting of steam, oil, gas and water.

Because the instrument scale is *evenly graduated*, you can read flow at full accuracy and with equal ease at any part of the range. No more squinting or troublesome interpolation due to crowded divisions at the low end of the scale.

Electronic integration adds up total flow accurately on a six-digit direct reading counter . . . tells how much fluid has gone through the metered line. Continuous integration eliminates the labor and uncertainties of totalizing from intermittent measurements. The new integrator features simplified design with only three major parts, all readily accessible for inspection and maintenance.

The compact electric meter body is easily mounted anywhere. It is designed of corrosion resistant materials to assure constant calibration. Electric transmission permits location of the recorder hundreds of feet from the meter body without loss of response or accuracy.

Call in your local Honeywell engineering representative for a discussion of your flow applications . . . he is as near as your phone.

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BROWN INSTRUMENTS

First in Controls

● *Important Reference Data*

Write for Bulletin No. 293-2, "Brown Evenly Graduated Flow Meter"

LUBRICANT

▲ One of the major problems confronting manufacturers and owners of centralized systems has been that of lubricant breakdown or separation in the lines, orifices and valves of the systems. Such separation, an inherent property of most soap base greases, especially when subjected to high pressures, clogs the orifices, lines and valves and requires frequent shutdown of the equipment and costly maintenance time to keep lubricant moving to the bearings they are supposed to lubricate.

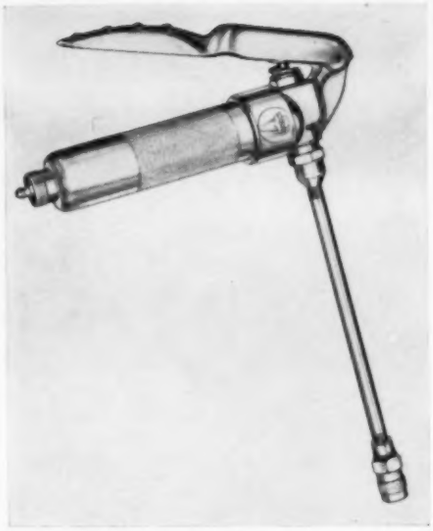
"Plastilube," the non-soap base lubricant, manufactured by Warren Refining & Chemical Co. has proved to be the answer to this problem. The lubricant, according to Warren engineers, will not melt nor will it separate in the system.

Several owners of centralized systems have reported that this lubricant has been used continuously since it was first marketed over two years ago without one minute's loss in maintenance time due to the lubricant clogging or separating.

LUBRICATING GUN

▲ This new gun offered by Lincoln Engineering Co. is designed for the following applications:

1. Lubrication of bearings on industrial machinery requiring injection of a small quantity of lubricant at extremely high pressure. (2) An auxiliary high pressure lubricator to service bearings requiring injection of limited quantities of special purpose lubricants. (3) Cracking "frozen" or clogged bearings on contractors' equipment without use of power-operated gun.



Gun provides complete range of pressures up to 10,000 psi. Easy one-hand push action eliminates fatigue —weighs only 2 lb. Long, hydraulic coupler extension permits reaching deep-seated and hard-to-reach fittings. Handles all pressure gun lubricants in any weather. Holds 2½ oz, can be refilled in seconds by engaging filler fitting on gun with control valve

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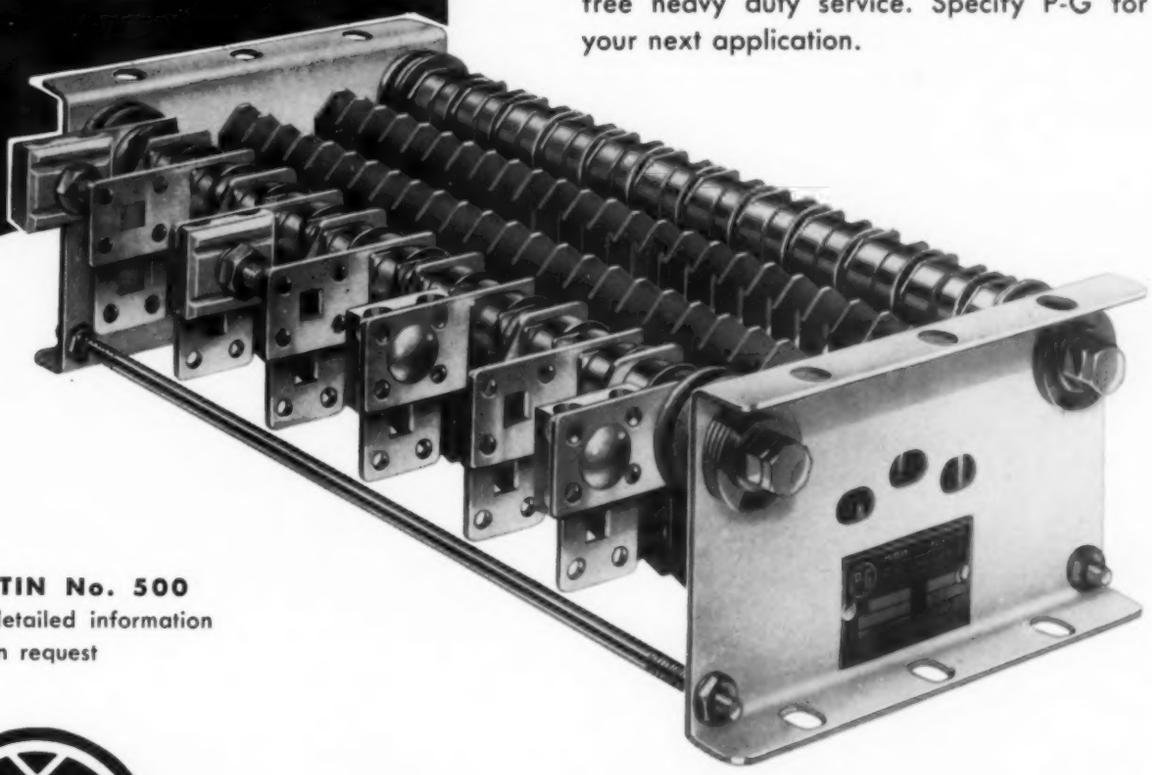

BULLETIN No. 500
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P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

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on hose from power — or manually operated pump. Gun can be cleaned by removing only one outlet check —no packings to replace.

THREAD INSERTS

▲ A Trenton manufacturer of induction furnaces for the foundry, die-casting and other industries has improved product design and overcome a serious maintenance problem by using stainless steel wire thread inserts in his assembly.

Substantially, these furnaces consist of two units; an inductor unit housing induction coils which carry up to 2,000 amperes; and a main housing, up to about 100 x 60 x 140 in. in size, which contains the hearth. The two sections are joined along machined faces by from 10 to 20 bolts, 5/8-11 or 3/4-10) depending on the size of the furnace and its attached inductor. These Ajax Engineering Co. furnaces range in power rating from about 20 to 1000 kw.

Because it is sometimes desirable to change or replace inductor units, ease of maintenance dictates that

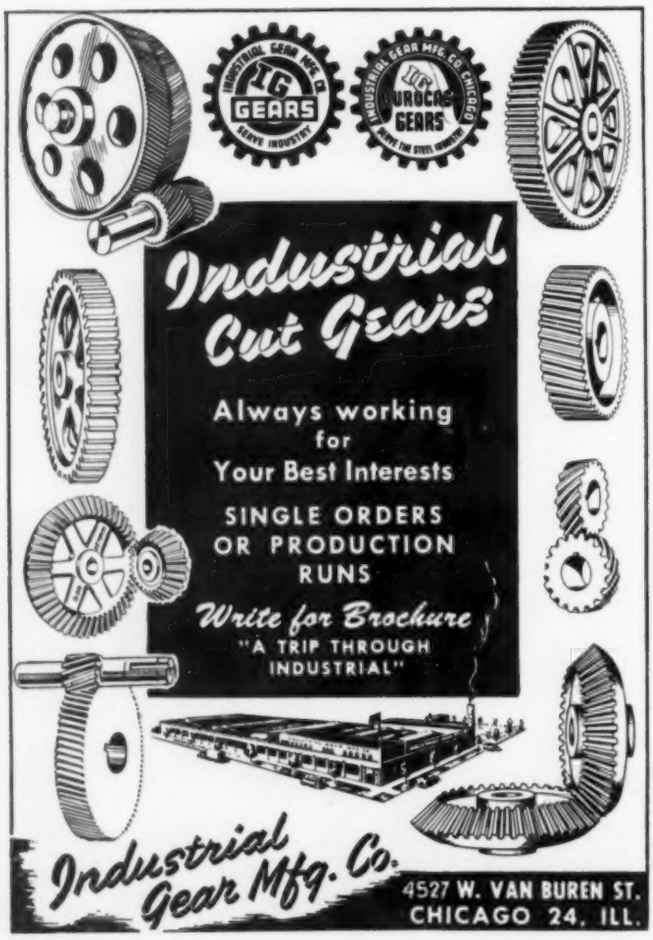
disassembly be simple and rapid. Yet to use flanges which would accept bolts and nuts would have introduced undesirable design elements. For one thing, such a flange would separate the two elements of the furnace by three to four additional inches. Also, it would add considerably to the cost of weldment.

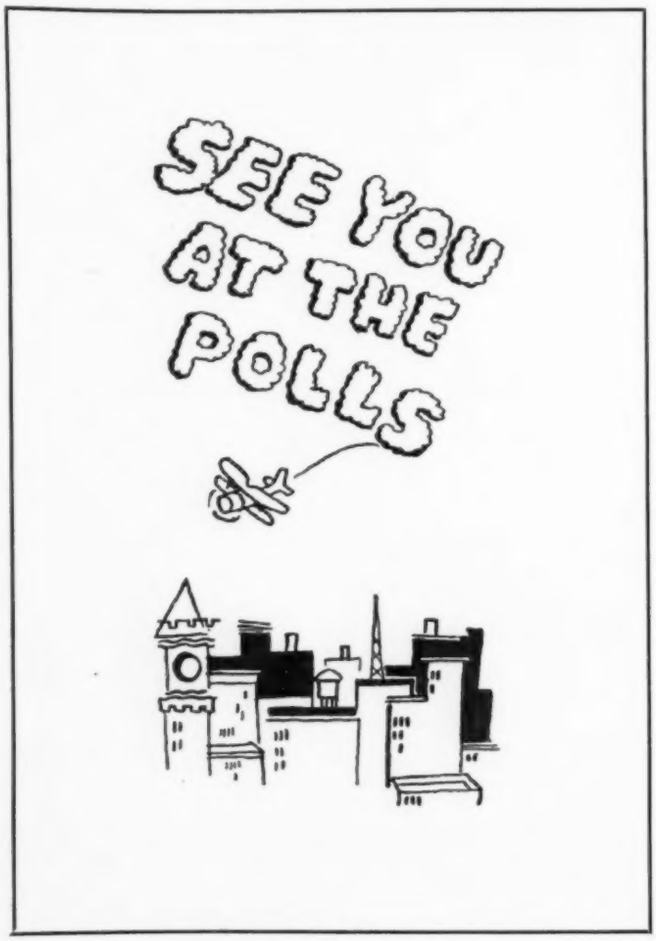
Accordingly, cap screws are employed in tapped blind holes. In use, these bolts are exposed to temperatures in the neighborhood of 200 F; also, they are in close proximity to an intense magnetic field.

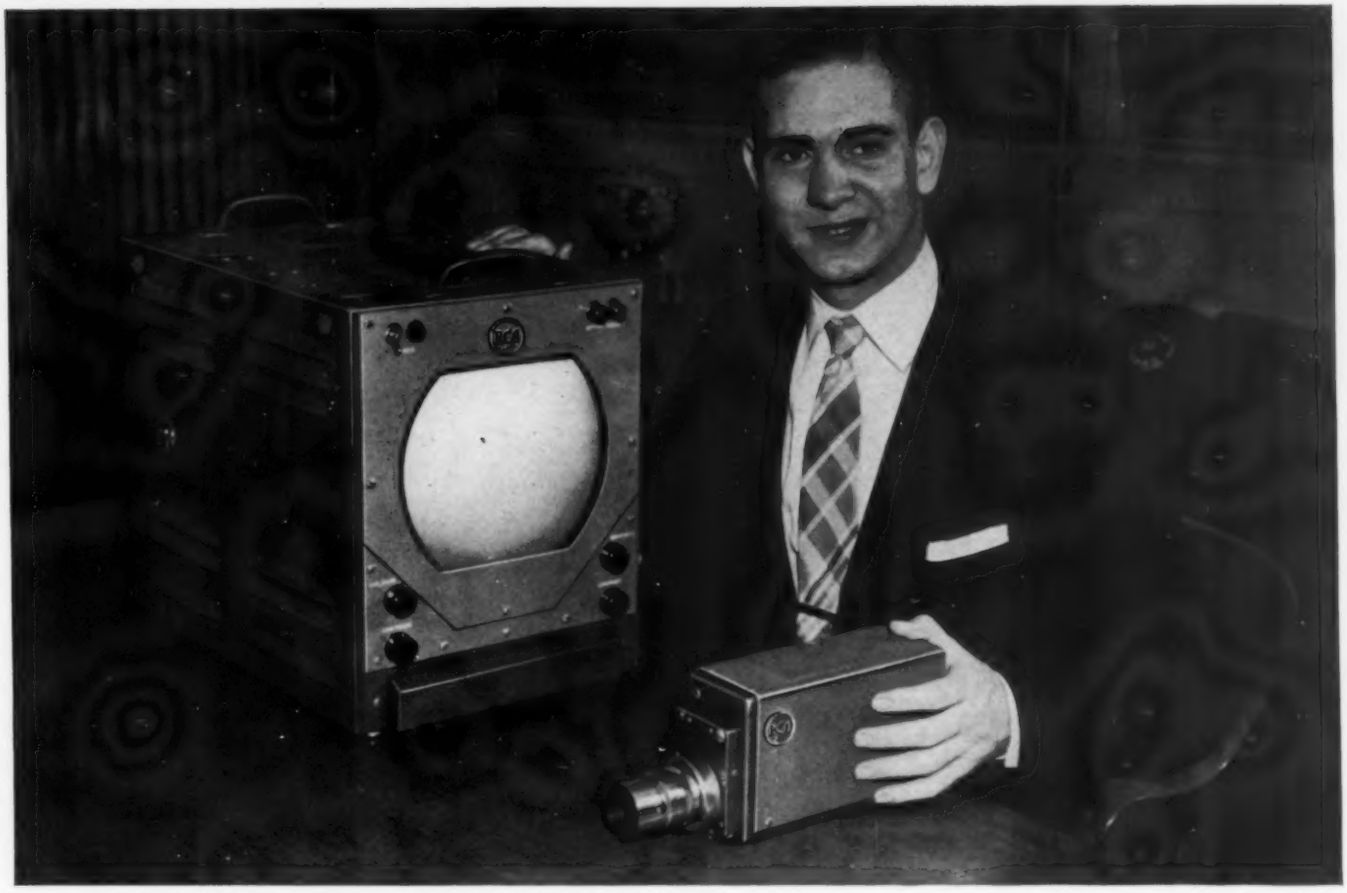
In early models, attempts to remove cap screws after the furnace had been in use for a considerable period met with a high proportion of failure. Often, the screws were found to have seized in the threads, with the result that they would twist off. The resultant cost in man-hours and increased down-time needs no elaboration.

Seeking to avoid this seizing, the manufacturer experimented with various classes of thread fit, and tried brass bolts, but neither expedient produced any improvement. The next remedy tried was the use of Heli-Coil inserts, thread inserts made of stainless steel wire precision-formed to a diamond-shaped section. They have abolished the seizing trouble, and have been adopted as standard equipment.

The performance of these inserts in high-heat applications where ordinary bolts become decarburized and brittle was not unexpected.





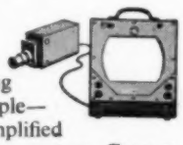


Announcing...RCA Industrial TV

offering 5 important features

Now RCA offers closed-circuit (wired) television specially designed for all types of industrial applications. By means of this new type of Industrial Television, you can maintain continuous visual checks on remote, inaccessible, or hazardous operations—from one or more points—with clear, high-contrast pictures. RCA Industrial TV has the following five important features.

1. Simplicity



A rugged camera tube (Vidicon)—operating on an entirely new principle—has made possible the simplified RCA Industrial Television system. Camera and monitor are connected by a single cable. No intermediate equipment is necessary. No more tubes than an ordinary home television set. To place in operation, merely connect to 110 volts, 60 cycle AC.

2. Compactness

RCA's new Industrial Television Camera (3″ x 5″ x 10″)—about the size of a 16mm movie camera—weighs only 7½ lbs. Using the Vidicon Tube, this camera is the smallest design available.

3. Ease of Operation

All controls—including those for the camera—are located on the monitor. For fixed operating conditions, once this system is set up, all necessary adjustments can be made with only two knobs . . . operation has been so simplified, anyone can learn to obtain a clear picture in a few minutes.

4. Picture Quality

With an RCA Industrial TV you can obtain high quality pictures without excessive illumination. Scanning frequencies are 525 lines, 30 fields, 60 frames, interlaced . . . the same as standard broadcast television. This permits home television sets to be used as auxiliary viewers.

5. Ease of Service

Carefully engineered simplification of circuits and components has resulted in dependability and ease of service and preventive maintenance. When you buy RCA Industrial Television, you can also buy an RCA Service Plan—complete nation-wide service by trained experts of the RCA Service Company.

For information on RCA Industrial Television, **ATTACH COUPON TO YOUR LETTERHEAD**

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Bethlehem Steel Co.
Sparrows Point, Md.

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Foreman Crane Department
Kaiser Steel Corp.
Fontana, Calif.

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Tennessee Coal, Iron & Railroad Division
United States Steel Co.
Birmingham, Ala.

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Lukens Steel Co.
Coatesville, Pa.

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Roll Designer
Republic Steel Corp.
Buffalo, N. Y.

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Brazilian National Steel Co.
Cleveland, Ohio

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Draftsman
Lukens Steel Co.
Coatesville, Pa.

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Maintenance Expediter
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Conshohocken, Pa.

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Conshohocken, Pa.

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Sparrows Point, Md.

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Coatesville, Pa.

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Otis Division
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Steel Co. of Wales, Ltd.
Port Talbot, Glam., Great Britain

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Rotherham, Yorkshire, England

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Weirton, W. Va.

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National Tube Co.
Lorain, Ohio

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Lorain, Ohio

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KAZUO KOMADA
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Yawata Iron & Steel Co., Ltd.
Yawata City, Japan

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Transportation Department
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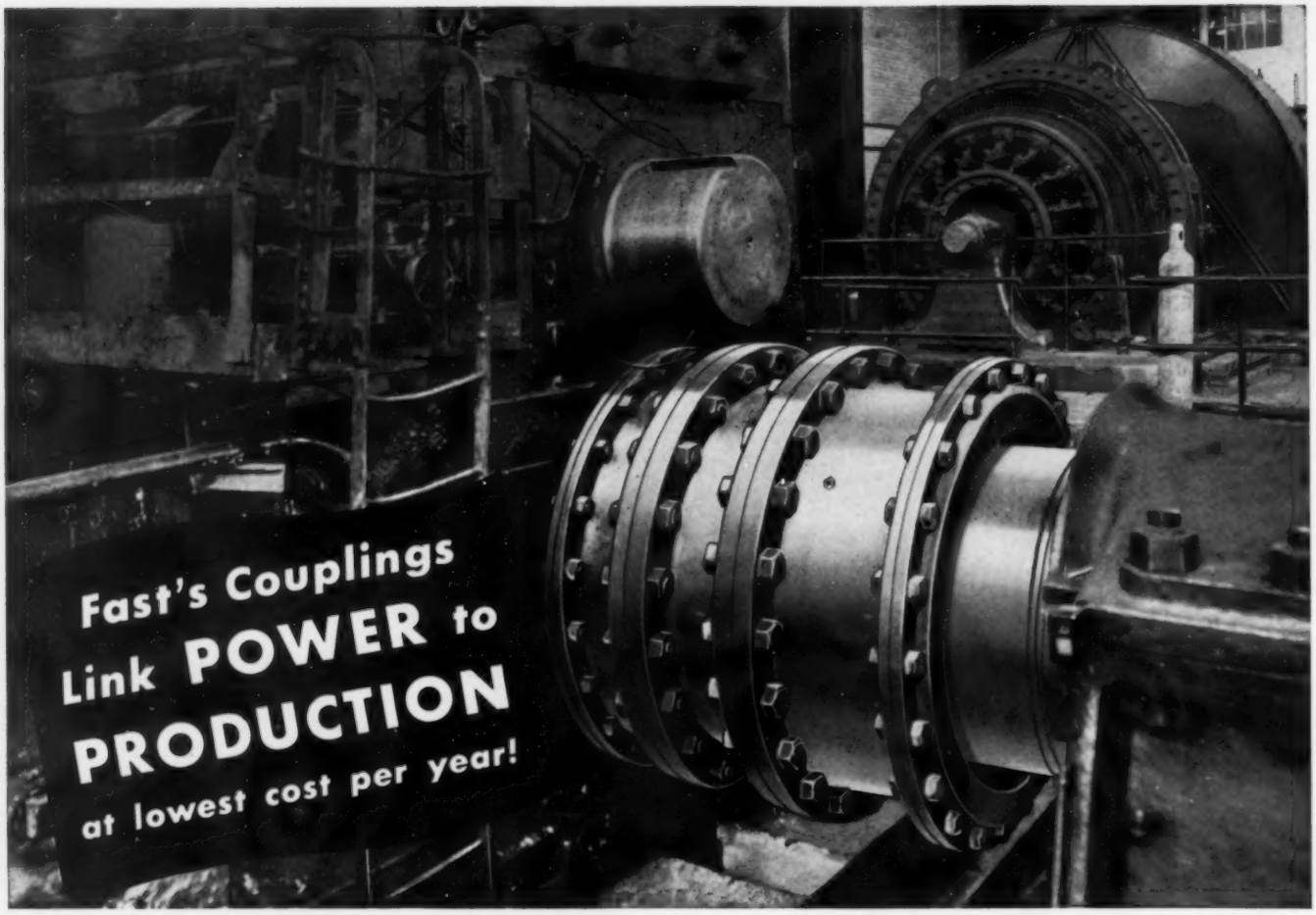
EUGENE H. SWETT
Looper—Combustion Department
Bethlehem Pacific Coast Steel Corp.
South San Francisco, Calif.



FAST'S Couplings usually outlast the equipment they connect!

ACTUAL cases on record show many Fast's Couplings are still in service after as much as 30 years of continuous operation! Time and time again, equipment has been replaced while the original Fast's Couplings remained on the job.

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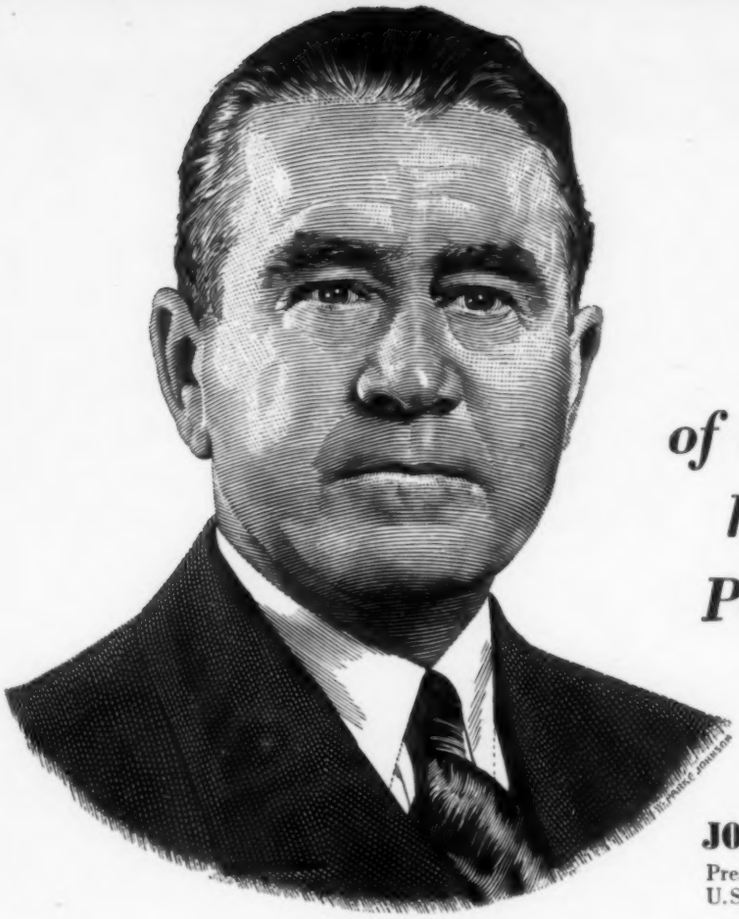

"More than 98% of our 27,000 employees have enrolled in the Payroll Savings Plan"

JOHN E. GOBLE
President, National Tube Division,
U.S. Steel Corporation

"We of the National Tube Division of the United States Steel, recognize that systematic saving through the Payroll Deduction Plan is an investment in the security of the Nation, as well as of the individual. We are proud of the participation resulting from a person-to-person canvass in our plants and offices. More than 98% of our 27,000 employees have enrolled in the Payroll Savings Plan—a complete affirmation of their faith in America. Such personal savings are the backbone of our free enterprise system."

Concisely, clearly, Mr. Goble cites three of the reasons why 98% of the 27,000 employees of National Tube are enrolled in the Payroll Savings Plan:

- recognition by management that the Payroll Savings Plan contributes "to the security of the Nation as well as of the individual."
- the purchase of Defense Bonds through payroll deductions is concrete affirmation of Americans' faith in America.
- a person-to-person canvass in plants and offices put a Payroll Savings application in the hands of every National Tube employee.

There is still another reason for National Tube's outstanding employee participation: *Mr. Goble's personal interest in the Payroll Savings Plan, and the conducting of the person-to-person canvass.*

State Directors of the Treasury Department, members of the Field Staff of the Payroll Savings Division, Volunteer Chairmen of industry groups—everyone associated with the Payroll Savings Plan—will tell you that every highly successful Payroll Plan is a reflection of the deep interest and personal effort of the company's top executive.

If you are the man who makes the top decisions in your company, ask today for a report of *your* Payroll Savings Plan, particularly, the percentage of participation. Then, call a meeting of your associates. Show them this statement of Mr. Goble's. Tell them you are going "all out" to put your company (large or small) in the front rank of those who can be justly proud of their Payroll Savings Plan.

A phone call, wire or letter to Savings Bond Division, U.S. Treasury Department, Suite 700, Washington Building, Washington, D.C., will bring prompt cooperation from your State Director.

If you are not the chief executive of your company, please tear out this page and send it to the "Big Boss" with your recommendation.

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The Airco 6035 scarfing torch keeps slabs and billets moving toward the rolling mill. Without interruption! It's light . . . sturdy . . . built for billet yard service. Monel metal heads and stainless steel tubes absorb the shock of high temperatures and rough handling . . . while "finger-tip balance" helps to keep operator fatigue from dragging down scarfing tonnages.

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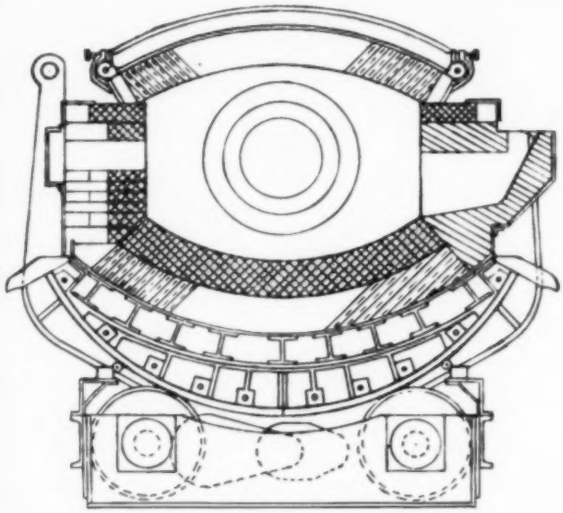
Here's how to HOLD THAT LINING in your holding furnace

Operators of Whiting* Cradle and similar types of holding furnaces use Taylor Sillimanite (TASIL) brick and cement to prolong the life of refractory linings. Recommended practice is to "*balance*" the super-duty fire brick lining with 9" of TASIL brick, laid in TASIL No. 301 Cement, for both side walls and bottom, in the areas subject to the damaging wash of molten iron and slag. (See refractory construction shown in engineering drawings below.)

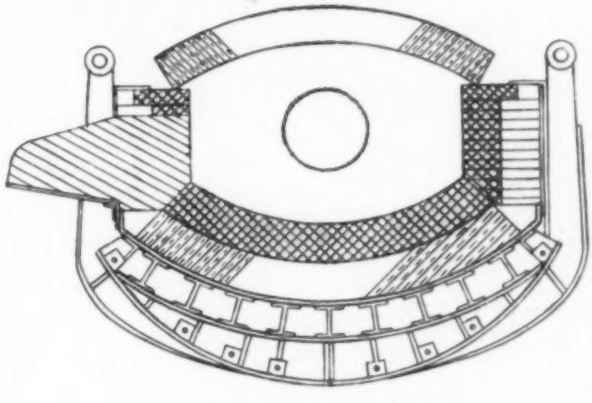
A TASIL "balanced" lining at one plant is averaging 6-8 weeks on side walls and 9-12 months on bottoms, with patching. TASIL was tried after a super-duty fire brick lining failed in three days because of joint attack and severe erosion at the metal line. This furnace is fired with pulverized coal and runs 700 tons per week of grey iron, tapped from cupola at 2750° to 2800° F.

Wherever you use fireclay-base, high alumina, kaolin or similar refractories, TASIL will give more effective service. Let a Taylor field engineer discuss with you the savings Taylor Sillimanite can make in your plant.

Tasil "Balanced" Lining In Whiting Cradle Furnace



Section through Pour-in Spout



Section through Pour-out Spout

TASIL sidewalls and bottom 9" thick. TASIL top course in sidewall 13½" thick.

= Taylor Sillimanite

* Built by Whiting Corporation, Harvey, Ill.

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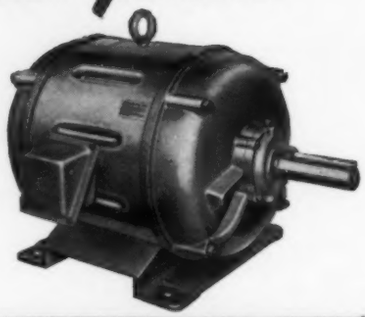
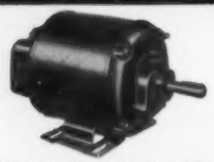
ELECTRIC MOTORS
...the choice of leaders in industry

Wagner Quality Motors *for your product or your plant*

When you select a motor from Wagner's complete line, you get a motor that is completely dependable in its specific application. You can choose from a wide variety of types and sizes. Here are a few of the motors in the Wagner line. At right is TYPE RP—open type polyphase squirrel-cage motor. It is drip-proof and suitable for all general purpose applications. 1/6 to 400 hp.

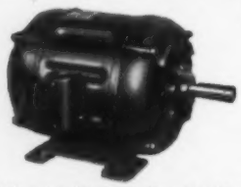


SINGLE-PHASE

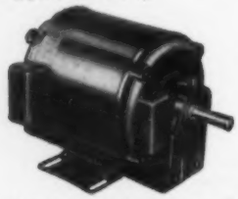


TYPE RB—*Split-phase Induction. For easy starting applications with high starting current. 1/20 to 1/3 hp.*

TYPE RK—*Capacitor-Start Induction. For general purpose applications requiring high starting torque—normal starting current. 1/6 to 3 hp.*

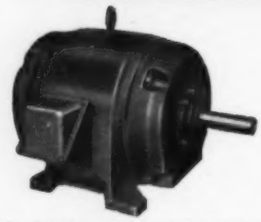


TYPE RG—*Repulsion-Induction. For high starting torque applications involving a very long starting period. 1 to 5 hp.*

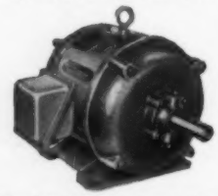


TYPE RA—*Repulsion-Start Induction. For general purpose applications with high starting torque—low starting current. 1/2 to 15 hp.*

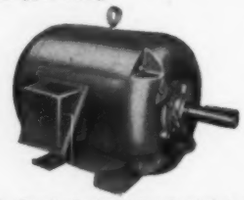
POLYPHASE MOTORS



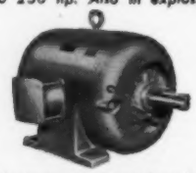
TYPE XP—*Splashproof. Protected against splashing or dripping liquids. 3/4 to 200 hp.*



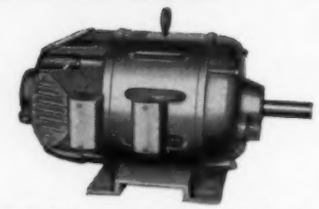
TYPE TP—*Totally-enclosed, non-ventilated. Fully protected. 1/4 to 15 hp.*



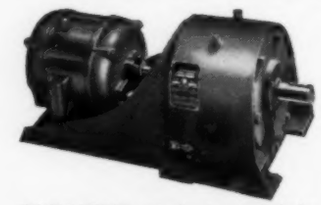
TYPE CP—*Totally-Enclosed Fan-Cooled. Protected against dirt, chips, abrasives or fumes. Steel frame. 1 to 250 hp. Also in explosion proof type HP.*



TYPE EP—*Corrosion-resistant Totally-Enclosed Fan-Cooled. Cast iron frame. 2 to 250 hp. Also available in explosion proof type JP.*



TYPE RS-1—*Wound Rotor. Constant or adjustable varying speed. 1 to 250 hp. TYPE RS-2 for intermittent service. 2 to 200 hp.*



GEAR MOTORS—*Single-phase or Polyphase. Open or enclosed types. 1/20 to 50 hp.*

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Book Reviews

▲ **"Ferromagnetic Properties of Metals and Alloys,"** by K. Hoselitz, Oxford University Press, 114 Fifth Ave., New York 11, N. Y., 317 pp., 5½ x 8½ in., price $8.00, is the eleventh volume in the series, "Monographs on the Physics and Chemistry of Metals," and is directed primarily toward post-graduate and industrial research workers. The author discusses present-day theories of the magnetization curve, and attempts to correlate existing theories with practice. The composition and properties of soft magnetic materials and magnetically hard alloys are described fully, along with the potential application of magnetic methods to metallurgical problems.

▲ **"Corrosion Testing Procedures,"** by F. A. Champion, 369 pp., 5½ x 8½, $6.25, is aimed primarily at the research worker and deals with common problems in the corrosion of metals. The author discusses in turn the choice and preparation of metal and corrosive testing of the metal, cleaning and examination of the specimen, and interpretation of the results. The publisher is John Wiley and Sons, Inc., 440 4th Ave., New York 16, N. Y.

▲ **"Imperfection in Nearly Perfect Crystals,"** was recently published under the sponsorship of the National Research Council, 490 pp, 5½ x 8½ in., price $7.50. This book is a summary of articles contributed by twenty scientists, presenting a cross-section of views and findings on imperfect crystals.

The major deficiencies in the knowledge of crystalline imperfections are discussed, along with details on a variety of imperfections, from both experimental and theoretical viewpoints. Numerous illustrations aid the presentation. The book is published by John Wiley & Sons, Inc., 440 4th Ave., New York 16, N. Y.

▲ **"North American Combustion Handbook,"** recently published by the North American Manufacturing Co., 4455 E. 71st St., Cleveland 5, Ohio, 320 pp, 6x9 in., price $2.00, is a much-needed addition to the industrial library. Containing 178 tables, charts, and illustrations, the book treats at length fuels, combustion analysis, heat transfer, fluid flow, burner equipment, combustion control, and combustion systems. Included also is a glossary of terms used in the combustion industry, the first ever published. Users of combustion equipment are provided with explanations of the theory of combustion, together with outlines for combustion heat transfer, and fluid flow calculations, and a discussion of combustion equipment with its selection and application. Newcomers to the field will find a simplified introduction to the elements of combustion in the first chapter. Though dealing principally with industrial heating with gaseous and liquid fuels, the volume also contains considerable information applicable to commercial heating and solid fuels. It is equally useful as either a text or reference.

▲ **"Handbook of Engineering Fundamentals,"** edited by O. W. Eshbach, in a completely revised 2nd edition, has been published recently by John Wiley & Sons, 440 4th Ave., New York 16, N. Y., 1324 pp, 5½ x 8½, $10.00. The many innovations which have occurred in the various branches of technology since the first edition appeared in 1936 have necessitated an up-to-date volume. To this end thirty-nine scientists have contributed their talents to the revision of the popular handbook. The section on mathematics has been revised to place greater emphasis on statistics, determinants, and vector analysis. A section of aerodynamics, stressing basic theory of aircraft design and performance has been included in the completely rewritten discussion on fluid mechanics. More detailed matter has been included in the treatment of engineering materials. The section on engineering law has been rewritten and presents a summary particularly valuable to those engineers concerned with contractual relations.

▲ **"Sampling Inspection by Variables,"** by Albert H. Bowker and Henry P. Goode, 216 pp., 6 x 9 in., is basically a collection of variables, tables and their operating characteristic curves. Comprehensive instructions and illustrated examples facilitate the use of these tables, which may be employed either as part of an inspection schedule or as a brochure of plans from which selections may be made. The book, published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., is priced at $5.00.

▲ **"Atomic Power,"** by Walter Isard and Vincent Whitney, 235 pp., 6 x 9 in., $4.75, is concerned, in the first half, with an analysis of atomic power potential for industrial use, with special reference to the iron, steel, and aluminum industries. The various economical, political, and social problems of atomic power, and the necessity of proper control plans comprise the second part of the book. The publishers are the Blakiston Co., 1012 Walnut St., Philadelphia 5, Pa.

▲ **"The Science of Flames and Furnaces,"** by M. W. Thring, of the British Iron and Steel Association, 416 pp, 5½ x 8½ in., price $6.50, stresses the gap between scientific knowledge and its application to flame-heated furnace research. Sections are devoted to such subjects as heat transfer, the science of furnace construction, thermodynamics of furnace heating, liberation of heat by combustion, aerodynamics of hot systems, and the application of the scientific method to furnaces. The author contends that solutions to the problems of furnace heating may be forthcoming if academic scientists, as well as engineers, are attracted to the field. The text may be obtained from John Wiley & Sons, Inc., 440 4th Ave., New York 16, N. Y.

▲ Bulletin 512, **"Analysis of Foreign Coals,"** may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at 30 cents a copy. This bulletin covers what is believed to be the best general information obtainable on sources, production, and analyses of foreign coals. The bulletin contains representative analyses of coals from Albania to Zamboanga. Tables showing world production of coal and lignite, and world resources of coals, brown coal, and lignite are also included.

(*Please turn to page 212*)

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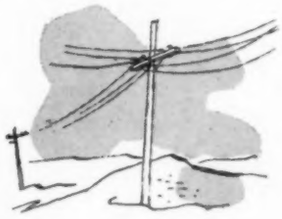

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FOR SALE: AI&SE yearly proceeding (16 volumes) 1940 to 1951 including "Modern Strip Mill," all in original cartons.
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Book Reviews . . .

(*Continued from page 208*)

▲ **"Practical Metallurgy for Engineers,"** fifth edition, has just been issued by the Research Staff of E. F. Houghton & Co., Philadelphia.

This edition represents more than a year's work of revision and checking to bring the previous edition up to date. It presents the latest standards and practices followed in the metal industry today and included also a discussion of future probabilities relating to new metals, new alloying elements and new types of heat treatment. The sections of the book covering heat treating are said to be among the most comprehensive published.

The revision has 120 pages more than the previous (1943) edition. New chapters include one on flame and induction heating to bring in new developments which have expanded the useful range of both these methods. Following the chapter on carburizing, the revision also contains a new chapter on "Other Surface Hardening Methods." The chapter on "Heat Treatment of Aluminum Alloys" has been expanded to "Heat Treatment of Non-Ferrous Alloys" in order to include magnesium and copper alloys as well as aluminum alloys.

In addition, revisions have been made throughout the book to incorporate the latest methods and data related to all phases of metallurgy, including the latest AISI steel classifications.

Since its first edition in 1923, the book has been a standard guide in the industry. The new edition is well printed and well illustrated, contains 599 pages, and sells for $3.50. For further information write to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

▲ **Bolt, Nut and Rivet Standards,** 256 pp, has just been published by the Industrial Fasteners Institute. This completely revised and enlarged book replaces the first edition, issued in 1941, and is the only publication which contains all current standards for commercial fasteners. It was published both to aid production in manufacturers' plants and as a service to users in acquainting them with accepted standards of nomenclature, dimensions, sizes and other practices.

Among the new standards included in the book are those for round head bolts (carriage bolts), plow bolts, track bolts, studs, slotted and recessed screws, socket head screws, small solid rivets, large rivets, unified screw threads, and the newly-adopted square and hexagon bolts and nuts unified dimensionally with Britain and Canada. There is also a large section listing weights and stock production sizes; and informative discussions on screw threads, gaging practices, fastener materials, manufacturing processes and a complete list of all recognized fastener specifications. Copies may be obtained at $3.00 per copy from the Industrial Fasteners Institute, 3648 Euclid Ave., Cleveland 15, Ohio.

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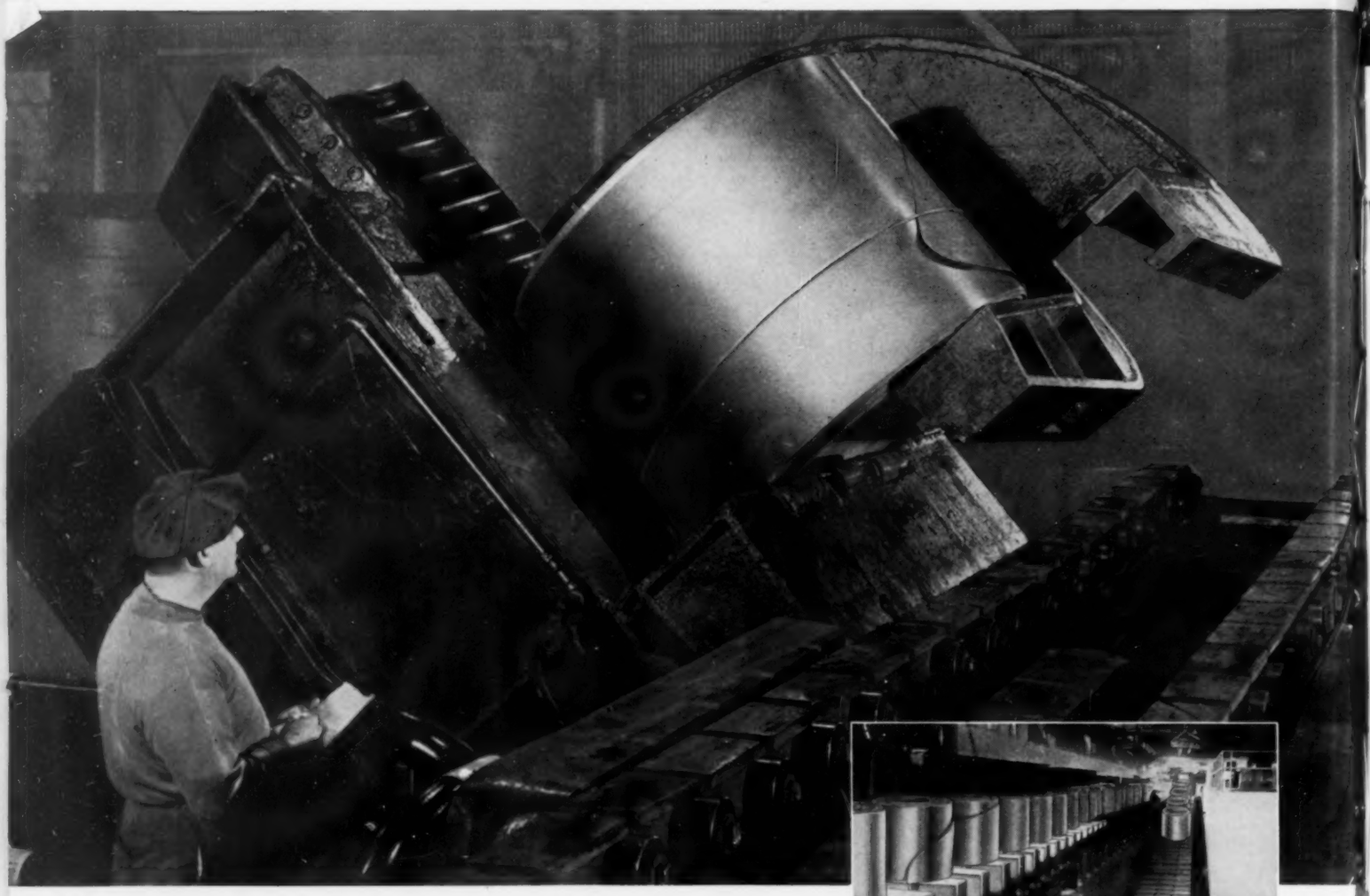

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